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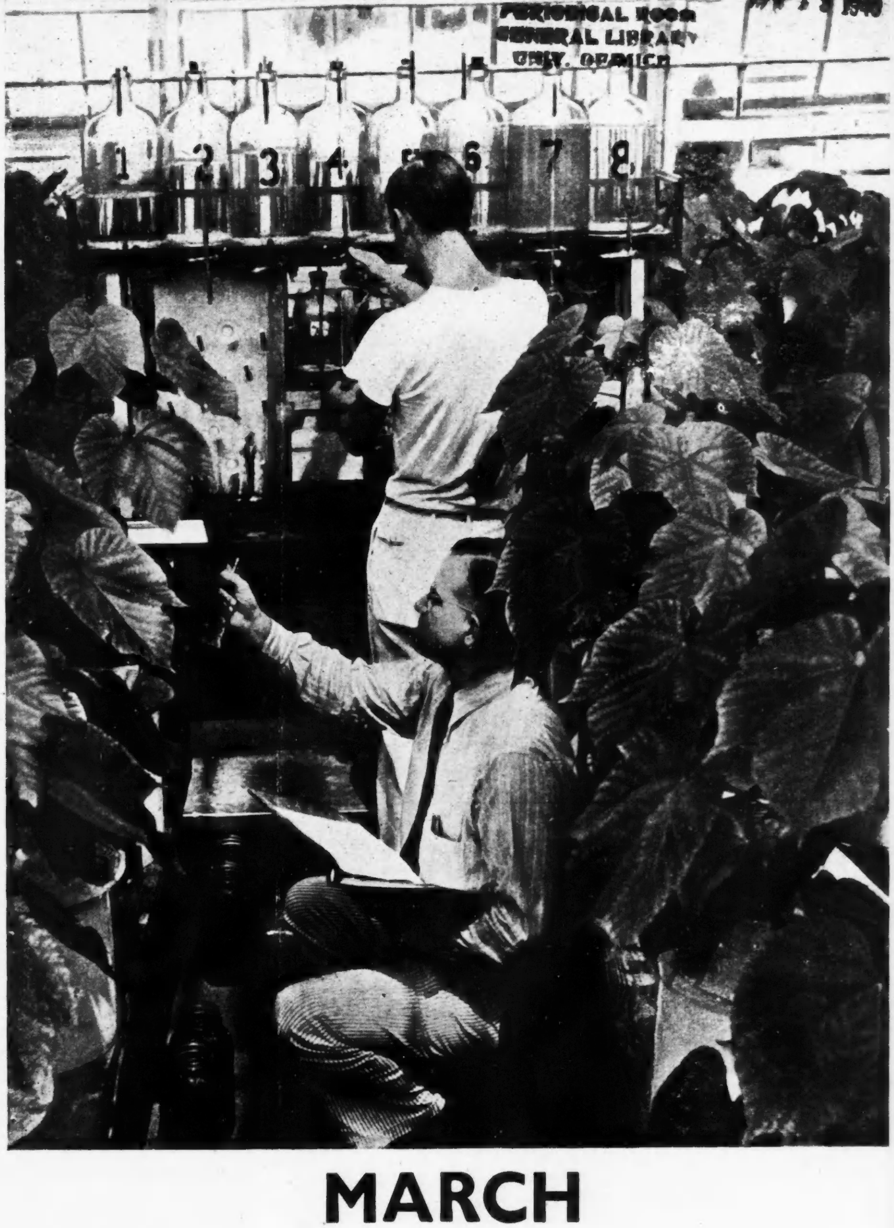

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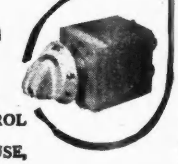

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THE MAGAZINE OF SCIENTIFIC PROGRESS

March, 1946 Vol. VII. No. 3

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Progress of Science

The Moon and the 8.35

A FEW days after the world had been told the story of the atomic bomb and of radar, a short, poignant letter appeared in *The Times* inquiring why science, which could produce these impressive results, was not also used for improving the amenities of everyday life—in particular, for solving the problem of making the 8.35 train run to time in a fog. The criticism is just. Man at the present day exhibits an almost ridiculous contrast between the extreme scientific and technical skill with which he makes a plastic compound from its raw materials or sends the voice of Tommy Handley to the ends of the earth, and the 'traditional' way in which he moulds the plastic into a cup whose shape is determined largely by its former suitability for cups made from clay, or listens to ITMA in rooms having a floor-level temperature 10° or 20° F. below that at head level.

Science has not paid sufficient attention to ameliorating the conditions of everyday life. Professor Bernal pointed out in 1939 that "cookery has not changed in its essential processes since palaeolithic times". And, if war needs forced biochemists to discover and publicise methods of cooking cabbage so as to retain the maximum amount of vitamin C, that was but a beginning to the full-scale attack that is needed on the problems involved in finding out the best ways to convert raw animal and vegetable matter into table fare. Our tea-pots still drip at each cup that is poured out, though scientific knowledge of the cohesion of fluids must by now have provided a way of preventing that trouble. Bernouilli's principle, which dates from the eighteenth century, has been applied to yield a non-splashing kitchen tap—yet most of our kitchen taps still shower us with water when turned on incautiously. The luckiest of men need a new 'wafer' razor-blade every few days, although more than ten years ago an American metallurgist used the process of nitriding to make himself a razor-blade which he was able to use daily for two years without even resharpening.

The tendency continues to operate even with some of the latest achievements of applied science. Radar has been used to make contact with the moon, and it is being rapidly developed in its application to peacetime navigation, but though Sir Robert Watson-Watt himself has called attention to radar's potentialities in connexion with rail transport we hear nothing of attempts to use it to solve the problem of the fog-bound 8.35.

There have, of course, been attempts to apply science to everyday matters. Perhaps the most notable till very recently was that associated with Rumford and the Royal Institution. Rumford was not only a very competent scientist and a genuine philanthropist, but also—what is rarer—a synthesis of the two. He applied his knowledge of the science of heat, which was probably more extensive than that of any other philosopher of his time, to such things as the design of stoves, fire-places and lamps, and to problems of fuel economy, with the object of improving the living conditions of the poor. When he investigated the relations between the nature of a surface and the quality of heat radiated from it, he hastened to deduce the very practical advice that the kettle should be black and the tea-pot highly polished. In 1799 he took the lead in forming the Royal Institution, whose intended role is expressed, in the title of its first prospectus, as "a Public Institution for diffusing the Knowledge and facilitating the general Introduction of useful mechanical Inventions and Improvements, and for teaching by Courses of Philosophical Lectures and Experiments the Applications of Science to the common Purposes of Life."

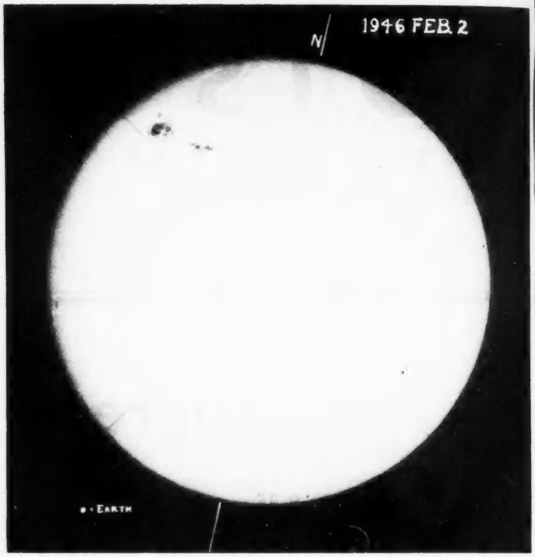
In the early years the Institution was run on the lines that Rumford had intended. It had its exhibition of mechanical inventions and its courses of lectures for mechanics, its kitchens and its lectures and experiments in cookery. But the times were not propitious for such a venture. Soon it changed to an institution that dealt with fundamental scientific questions and to some extent with the application of science to manufactures and industry, rather than to the more homely aspects of life. The change was inevitable. Nor is it to be regretted, for thus the Royal Institution came to play a very notable part in the development of science—and what it did in that way was far more important *at that time* than any of the philanthropic actions for which its founder had intended it. At that time, and for more than a century after, the main tasks for science were to develop itself and

to develop the general technique of industry—and attempts to tackle more homely problems, except on a minor scale, were bound to fail.

But times have changed. The development of fundamental science must, of course, go on, as must its even more intensive application to industrial techniques. But today, in what the former U.S. Vice-President, Henry Wallace, so aptly called 'The Century of the Common Man', it becomes necessary that science should also seriously tackle the problems of everyday life. Indeed it has begun to do so, but so slowly and in so small a way that it is necessary to inquire what factors restrain it.

Among the restraints is an obvious organisational one—it has hitherto been nobody's business to take care of these matters. The industrial scientist must necessarily be guided by his firm's search for profits—and the application of science to everyday life is seldom the most profitable line for commercial enterprise to adopt; indeed it may often be the reverse—an ever-sharp razor-blade would not be likely to increase a razor-blade manufacturer's turnover. The academic scientist has usually ignored these more mundane problems. And indeed, in general, he has been right to do so, since his chief social function is the advancement of fundamental scientific knowledge—though one might hope that in future the academic worker will be willing to pay some attention to these problems as a 'side-line', in co-operation with those whose special concern such problems are. Though the application of science to everyday life has in the past been nobody's business it need not remain so. Though it is not profitable to the industrialist as such it is profitable to the community as a whole, and it becomes the duty of the State to encourage such application and itself to create, where necessary, organisations for the purpose. Indeed one of the minor scientific developments of the war, which has been largely overshadowed by more startling matters like the atomic bomb, is the attention of certain Government scientific departments to just the type of problems we are discussing—the work of Ministry of Food scientists, for example, to say nothing of the less-known work of the Wartime Social Survey. It is to be hoped that the Government will take increasing responsibility for these aspects of the application of science.

There are other restraining factors of a less tangible nature. Men and women live largely by tradition and habit. To think out every step in life from first principles would be impossible—necessarily we tend to reserve our faculty for logical thought for situations in which it is specially needed, letting instinct, habit and tradition take charge of the rest. And so, because they are matters of habit, we tend to ignore the minor aspects of everyday life which might be improved. The housewife accepts from habit the splashing tap or the accumulation of dust in corners, never stopping to think that her work would be lighter if right-angled corners were turned into curves. No doubt an educational campaign to encourage the general attitude of 'living in a revolution'—a scientific revolution—would create a greater tendency to question the perfection of the present, even in small things. Yet the fact must always be faced that in the small things of life, the things whose importance comes only from their repetition, there is a very strong tendency to accept without question that which already exists.

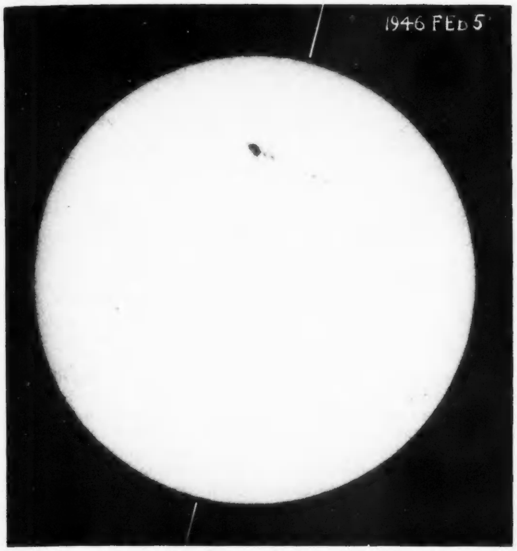


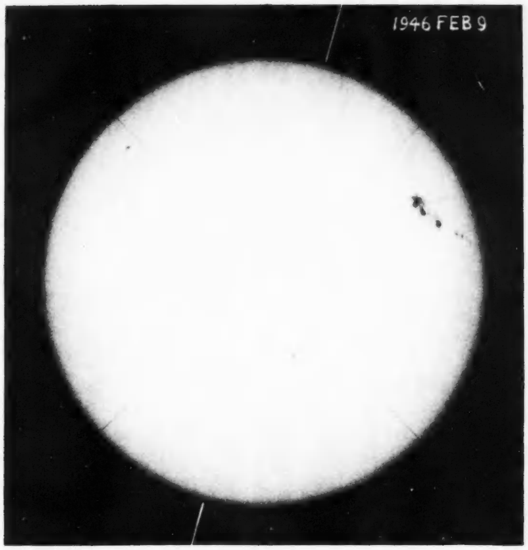
But there are now available techniques for overcoming this difficulty. Operational research has developed methods for ensuring that those matters which are usually accepted without thought shall be subjected to scientific analysis. (More public information on operational research would be welcome at the present time, in order to facilitate its peacetime applications.) The complementary technique of evaluating the needs of the population as a whole by means of sample surveys has also been greatly extended by the Wartime Social Survey. These two techniques would form the core around which to build the more vigorous application of science to the problems of everyday life. Naturally they could not provide the whole story and almost every branch of science would have to play a part. Nor must this be thought of as work appertaining solely to an organisation for consumer research. Such an organisation, under Government auspices, would have a central part to play in the new developments, but one of its most important functions would be to diffuse through the whole field of applied science a feeling of responsibility for the application of science to the little things of life.

Sunspots and Radio Noise

A GREAT group of sunspots was brought into view at the sun's eastern limb on January 29 and was carried by the solar rotation to the sun's central meridian on February 5.

Two giant spots appear to have been involved and measurements made at the Royal Observatory, Greenwich, showed these two component spots had a maximum area of nearly 1/200th of the sun's visible hemisphere (a considerably larger area than that covered by the group of January 1936, hitherto the largest observed during the era of photographic recording—that is, since 1875.) For many days this group, extending across 210,000 miles of solar longitude, was clearly visible to those who used no





Three photographs of the recent giant group of sunspots taken at the Royal Observatory, Greenwich, on February 2, 5, and 9 respectively. Spots move across the sun's disc in about 13½ days owing to the sun's rotation, the axis of which is indicated by the short white lines. The thin cross lines are the images of spider threads at the principal focus of the telescope and used in the measurement of spot positions. This was the largest group of spots yet recorded at Greenwich since the photographic record of sun-spots was begun there in 1875. The total area of the component spots reached nearly 1/200th of the sun's hemisphere—or more than 110 times the cross-section area of the earth.

optical aid beyond a piece of dark glass (or photographic negative) to cut out the sun's glare.

Its unexpected arrival so early in the new sunspot cycle has enabled Sir Edward Appleton and the Operational Research Group of the Ministry of Supply to confirm the existence, previously suspected, of a continuous short-wave radio emission originating in the disturbed spot region. It has long been accepted that, since the sun emits electromagnetic waves in the form of heat and light, it must also emit wireless waves of extremely low intensity. Normally this intensity is so weak as to be quite undetectable on radio receivers in the 1-10 metre band. When, however, there is a large and active group of spots on the sun's disc, the solar radio emission increases up to 100,000 times: it may then be detected by sensitive receivers, of the Army radar type, for instance, especially those possessing directional receiving aerials which can be pointed to the sun. The effect produced in headphones and loudspeakers is that of a hissing noise, hence the term 'radio noise'. Such noise was heard occasionally by wireless amateurs as far back as 1936, and again in February 1942 by Mr. J. S. Hey, of the Ministry of Supply, using a standard radar set. From their reports Sir Edward Appleton concluded that the emission must have had its origin in the active sunspots visible at those times.

Despite great progress in solar physics, much uncertainty still exists as to the nature and origin of sunspots, as well as of the eleven-year cycle which they exhibit in common with certain other solar phenomena. The central umbra of a sunspot is at a temperature fully 1000°C. below that of the rest of the sun's visible surface or photosphere: it thus appears black merely by contrast with its much hotter surroundings. The maintenance of this region of reduced temperature, covering an area of many millions of square miles, seems to imply the continuing uprush of gases from regions of higher to those of lower pressure, with consequent cooling by what is known as 'adiabatic expansion'. Magnetic fields are associated with all the larger spots: spectroscopic studies (whereby the intensity and polarity of these magnetic fields are investigated) indicate the existence of a vortex motion in the hot ionised gases, having a direction of rotation—clockwise or anti-clockwise—which determines the polarity of the field. We may thus regard a sunspot as, in some respects, analogous to a terrestrial cyclone, but with effects vastly more extensive and catastrophic, inasmuch as the sun, unlike the earth, is wholly gaseous, possessing temperatures ranging from 20,000,000° at its centre to 6000°A. in the visible surface layers.

Other characteristic features are the jets of luminous gas—the sunspot prominences are of several well-recognised types—moving at speeds up to 50 miles per second along thin curved trajectories which give the appearance of following the magnetic lines of force. In the past decade much attention has been concentrated upon the solar *flares* which occur only in the disturbed regions surrounding sunspots. (A flare may be described as a small area of the sun's surface which shows the hydrogen spectral line in strong emission instead of absorption.) Flares have been closely observed since 1934 as a result of international co-operation under the auspices of the International Astronomical Union. Analysing these records, H. W. Newton, of the Greenwich Observatory, has established the occurrence of a remarkable train of events, set in motion by the appearance of an intense flare. The whole process may be summarised as follows:

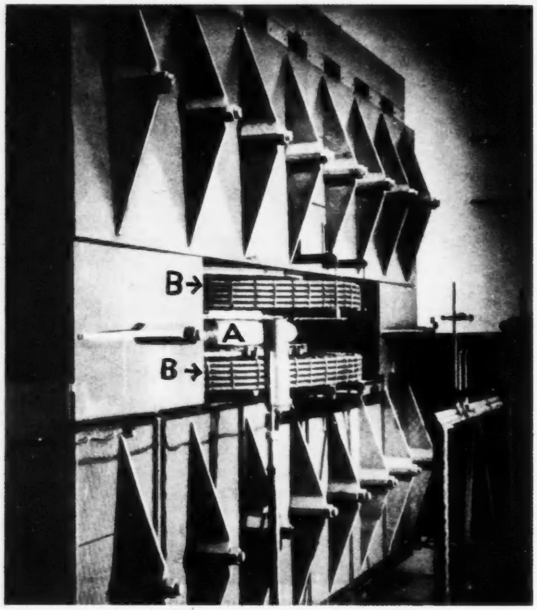


FIG. 1.—The 100 million volt betatron. The principal part is a huge laminated electromagnet made of 130 tons of silicon steel. The intense magnetic field is concentrated in the horizontal space between the two pole faces; between these lie the primary coils (*B*) and the vacuum tube (*A*).

(1) An intense flare emits ultra-violet radiation, reaching the ionosphere in a period of about 8 minutes and at the same moment as the flare is seen in the visible wave-lengths. This 'burst' of ultra-violet leads to the formation of an absorbing 'blanket' underneath the Heaviside layer so that short-wave radio is strongly absorbed there. The result is observed as a radio fade-out in the sunlit hemisphere of the earth. Associated currents of electricity in the ionosphere sometimes cause a simultaneous small disturbance of magnetic needles, known as a 'crochet'.

(2) There is a newly formed, cone-shaped stream of charged atoms ejected from the sun at the time and place of the flare.

(3) The arrival of this corpuscular stream begins about 26 hours later, reaching the earth in a 'head-on' encounter if the direction is favourable. The charged atoms spiral in along the lines of force of the earth's magnetic field and give rise to a great magnetic storm —magnetic needles may oscillate with an amplitude of of 1° or 2°. Optical effects—the *Aurora Borealis*— accompany the magnetic storm. The Aurora is nature's great 'advertising sign', indicating the arrival from the sun of particles which excite the atoms high in the earth's atmosphere, causing them to emit light by a process similar to that which occurs in a neon tube.

It is to be expected that the newly discovered phenomenon of short-wave radio emission from the sun will be actively studied by scientists during the coming period of maximum solar activity, 1947-49. If a connexion with the short-lived flares can be established, it may well point

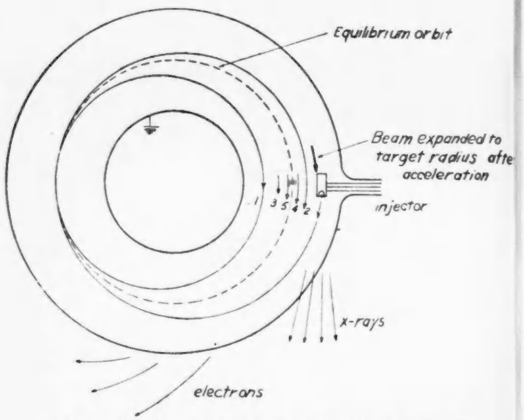


FIG. 2.—Electrons are injected into the ring-shaped vacuum tube and they proceed through positions 1-5 as they revolve. Eventually they settle down in the orbit shown by the dotted line. The orbit can be expanded by sending a current pulse through small wires fastened on the surface of the poles so that additional momentum is given to the electrons; deflected on to the back of the injector (as indicated in the diagram), they produce X-rays.

to the origin of the radio waves in atomic disintegrations occurring in these regions. Alternatively, the radio emission may derive from gigantic 'thunderstorms' occurring in disturbed areas of the solar envelope, in which case it might differ only in degree from the familiar terrestrial 'static'.

The Betatron

THE contrast between the simple apparatus that Rutherford and the other pioneers used in their studies of the atomic nucleus and 'the vast torture-chambers of the atom', as Professor A. S. Eve has described modern instruments such as the cyclotron, is emphasised with each new machine that is constructed. The demand for high energy particles for bombarding atomic nuclei has led to the development of a number of ingenious instruments. The latest addition to the series is the betatron—so called because it delivers high-speed β-particles or electrons, as opposed to the positive ions which are accelerated in the cyclotron. Protons and deuterons with energies up to about 20 million volts have been produced by the cyclotron. The latest betatron, built by the General Electric Company of America and weighing some 130 tons, produces electrons of 100 million electron-volts energy* (Fig. 1).

The fundamental principle of the betatron was suggested as long ago as 1922, and seven years later Dr. E. T. S. Walton, then working with Rutherford, calculated the conditions necessary for its successful operation. It was

*An electron which has been accelerated by a potential difference of 1 volt is said to have an energy of 1 electron-volt. Such an electron travels at a velocity of 370 miles per second. For higher accelerating voltages the speed increases as the square root of the voltage—so that a 10,000 volt electron travels at 3700 miles per second—about one fifth the speed of light. At still higher voltages the speed of the electron does not increase so rapidly but *gradually* approaches the speed of light—a million-volt electron is travelling with about 95% of the speed of light. At these high voltages the energy resides in the mass of the particle which increases very rapidly as the speed nears that of light. The cyclotron accelerates positive ions to energies of the order of 20,000,000 electron-volts, but the velocities of these particles are not so large owing to their greater mass.

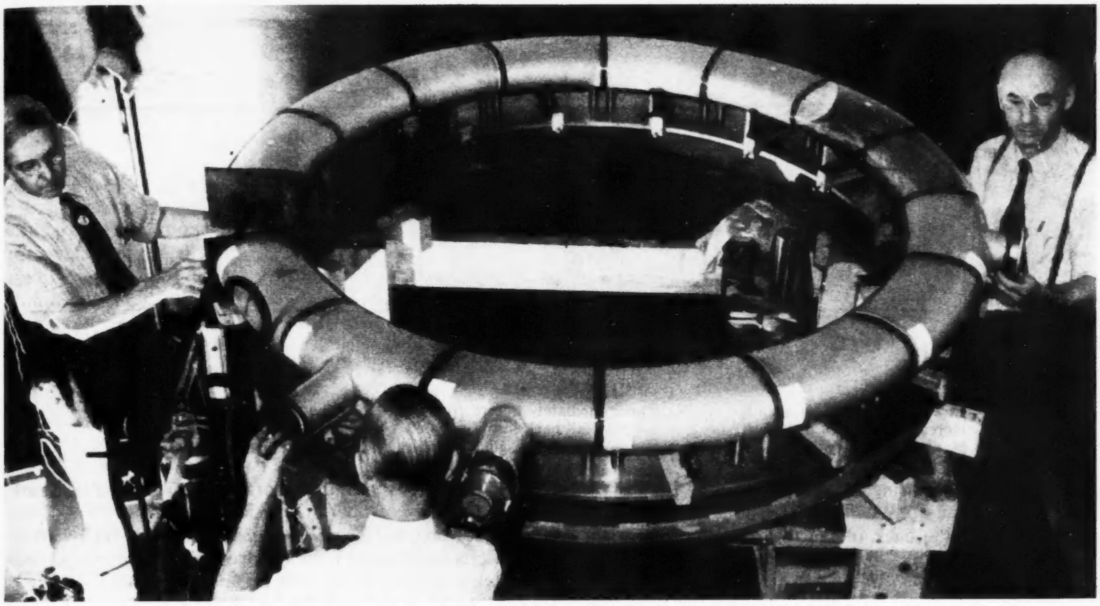


FIG. 3.—The vacuum tube is made up of 16 moulded Pyrex glass sections which are sealed together to ensure the required high vacuum.

not until 1940, however, that Walton's predictions were fulfilled as the result of Professor D. W. Kerst's work at Illinois. The 100 million volt betatron had been completed by the summer of 1943, but the censors forbade mention of it at the time. In 1942 Professor Kerst made the calculations necessary for a 250 million electron-volt betatron. Construction of this instrument is now in progress. Recently it became known that the Germans had been working on the same idea. Meanwhile Dr. E. M. McMillan of Professor E. O. Lawrence's laboratory at Berkeley, California, has announced that work is in progress on a new type of accelerator called the 'synchrotron' which combines the principles of the cyclotron and the betatron; this is expected to produce 300 Mev electrons. It is understood that one betatron is already working in Britain, and that a new model under construction here will give accelerations of the same order as those obtained in the United States.

In principle the action of the betatron is similar—homologous, that is—to that of a high-voltage transformer. In the transformer two coils are wound on a common magnetic core, the high-voltage or *secondary* coil having many more turns than the *primary*, the low-voltage coil. An alternating voltage is applied to the primary; with ten times as many turns of wire in the secondary as in the primary, the voltage induced in the secondary is ten times that applied to the primary. In the betatron the secondary coil is replaced by a single ring-shaped vacuum tube (Fig. 2). Electrons are shot tangentially into this tube, where they are swung into a circular path by the magnetic field. The current in the primary is increasing, and so, too, is the strength of the magnetic field. At each revolution round the vacuum tube the electrons gain as much energy as they would have done in a single turn of a secondary transformer coil. When the voltage in the primary reaches its maximum, the magnetic field is distorted in such a way that the electrons are switched out of their circular orbit and made to strike a target. In the 100 million volt betatron the electrons circle an orbit 66 inches in diameter 250,000 times during the quarter cycle ($\frac{1}{240}$ seconds) in which the magnetic

FIG. 4.—The upper yoke of the electromagnet has been removed, and the vacuum tube is seen in position, surrounded by the primary coils.

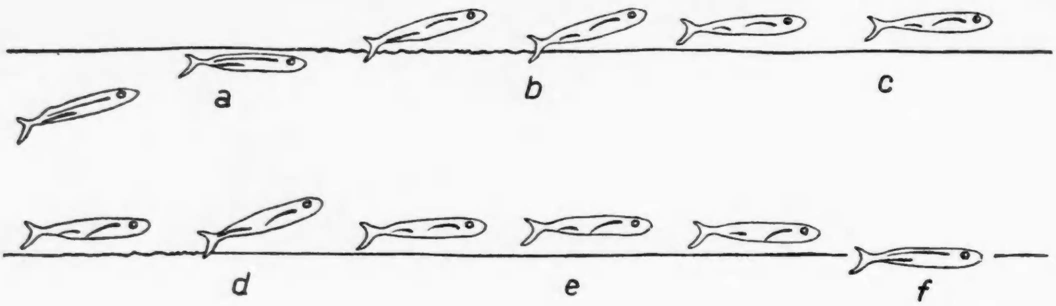


FIG. 5.—Diagram of a glide. (*a*) Position immediately before emergence. (*b*) The 'taxi'. (*c*) Glide with increasing angle of the wings. (*d*) The fish may fall back into the water or, as here, speed may be regained by renewed taxi-ing. (*e*) The second 'taxi' makes a second glide possible. (*f*) The fish returns to the water.

field is increasing; during that period they travel a distance of about 330 miles. When the target on to which they are deflected is the back of the injector from which they started, they produce X-rays; the October 1945 issue of the *Journal of Applied Physics* (which gives detailed information about the betatron) contains a reproduction of a radiograph taken through 4 inches of steel with these X-rays, which give much greater penetration than 2 million volt X-rays.

The main problem in the design of the betatron lies in ensuring that the electrons settle down in a stable orbit of constant radius; the electron stream is liable to start spiralling, after a few revolutions, in towards the middle or outwards. The electrons must also be prevented from drifting upwards or downwards on to the walls of the vacuum chamber; this is liable to happen as a result of collisions with stray gas molecules in the vacuum chamber. The magnetic field has to be carefully distributed to this end, and the right distribution is achieved by correct design of the pole pieces of the magnet. Final adjustments are made by altering the spacing between the two pole pieces; the delicacy of this adjustment may be judged from the fact that the radius of the electron orbit can be altered by one-tenth of an inch by raising the top half of the 130-ton instrument by $\frac{1}{300}$th of an inch.

Few details are yet available as to what the instrument can do, but of great fundamental interest is the announcement that mesons had been produced with its aid. The meson is one of the fundamental particles and has a charge of + or − 1 and a mass about 200 times that of an electron. Its existence was predicted theoretically by the Japanese worker, Yukawa, in 1934 and it was discovered is cosmic ray tracks two years later by Anderson working in America. According to present views the primary cosmic rays are protons of very high energy which, by colliding with nuclear particles in the outer layer of the atmosphere, cause the emission of two types of meson, one having a very short lifetime (10^{-8} seconds) and the other lasting long enough (10^{-6} seconds) to reach the surface of the earth before decaying into an electron and a neutrino. The meson plays a very important part in theories explaining the stability of atomic nuclei—it has been called the 'glue' which keeps the protons and electrons together, and its first production in the laboratory represents a landmark in the history of nuclear physics.

According to *General Electric Review*, the high-velocity particles generated by the betatron transmute copper into nickel, and silver into cadmium and palladium.

A useful article on the historical development of the betatron by Professor Kerst has appeared in *Nature* recently (1946, Vol. 157, p. 90).

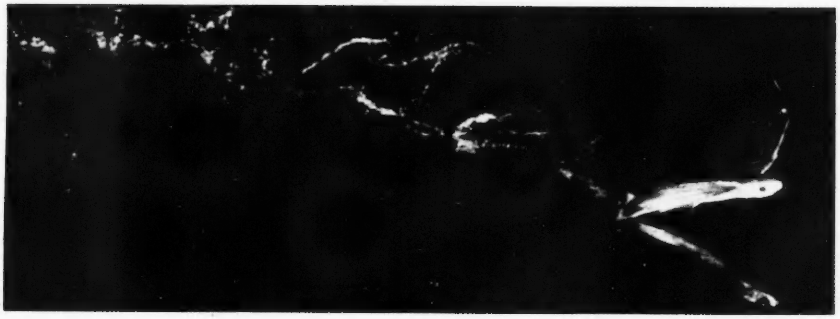
Flying-fishes

THAT there should be fish capable of flight still seems astonishing, even though the phenomenon has been observed by innumerable voyagers and is commonplace in tropical waters. Until recently the biologist was in no better position to watch the flight of flying-fish closely than was the layman. All that could be seen before the ciné-camera was turned on the flying-fish can be summed up as follows: the fish emerges from the surface, glides in the air for a few seconds, and then enters the water again after travelling for some tens of yards.

Cinematographic study has enabled the flight to be analysed minutely and timed accurately. Dr. G. S. Carter described some of the results so obtained when he lectured to the Linnean Society last month; the lecture followed the lines of his recent article in *Endeavour* on 'The Flight of Flying-fishes' (1945, Vol. 4, No. 16).

The sequence of events that take place when a flying-fish leaves the water is shown schematically in Fig. 5. The fish breaks the surface at swimming speed—about 15-20 miles an hour. Surprisingly perhaps, the fish is almost horizontal at the moment it emerges.

The fish does not begin its glide straightaway. Instead, for a period of about a second, it proceeds to taxi along the surface. The threshing of the surface by the tail fin, which gives added speed, is clearly seen in the photograph (Fig. 6), taken by Dr. H. E. Edgerton and Dr. C. M. Breder, two American workers who have applied the ultra high-speed camera to this study. The air-speed figure estimated by various authorities varies between 35 and 55 m.p.h.; Dr. Carter suggests that 40 m.p.h. is probably the highest speed the fish achieves in flight. Then follows the glide; usually this lasts for not more than 4 seconds—the



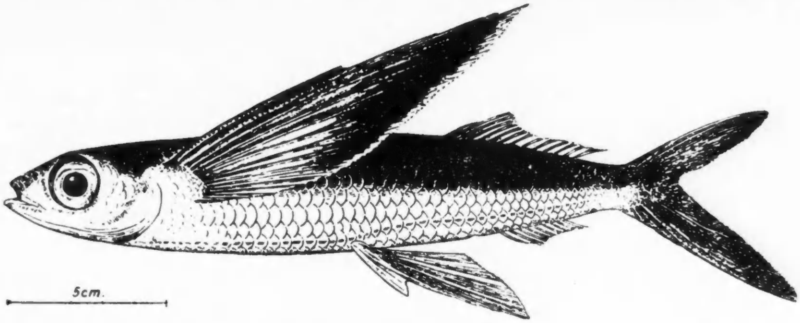


FIG. 6 (*above*).—A photograph taken by Edgerton and Breder, showing the V-shaped trail left in the water by the tail. Vibration of the tail—about 50 beats a second—gives speed for the 'take-off'. FIG. 7.—A typical flying fish, *Cypselurus lütkeni* (from Brunn).

average gliding-time is just over 2½ seconds—and carries the fish 40-50 yards in still air, somewhat farther if there is a following wind.

These 'average' glides are of the right order judged by conventional aerodynamic standards. Wind-tunnel experiments carried out by the Russian, W. Shoulejkin, with a model of the fish gave results corresponding to a glide of 62 yards and of 6·2 seconds duration if the initial speed was 34 m.p.h. This is slightly better than the performance usually put up by the fish, but this is to be expected since the model would have slightly cleaner lines than the fish itself. The experiment was repeated by Dr. Carter (with the co-operation of Dr. L. G. Whitehead), in the wind tunnel of the engineering department at Cambridge. They used an actual fish—a preserved specimen that they rigged up so that its wings were expanded to the area presented in natural flight. With an initial speed of 40 m.p.h. the preserved fish, they estimated, would glide for 1·74 seconds and a distance of 30 yards. This performance is thus not as good as in nature; one would anticipate this, for a living fish would be able to control the slope and camber of the wings with more finesse, while it would probably present far smoother contours than a preserved fish and give less resistance.

The matter is by no means closed, however. There still remain several things that require scientific explanation. The experiments of Shoulejkin and Dr. Carter shed no light on the exceptional flights, lasting 10-13 seconds, that have been recorded by reliable observers. Dr. Carter wonders whether the 'cushioning effect' that gives aeroplanes a lift greater than normal and that is most marked when planes are very close to the ground may also operate with flying-fish. Another point for investigation: the fish flies with its mouth open, thereby spoiling the streamline but presumably enabling the fish to continue to breathe in through the mouth and out through the gills. If that is so, some anatomical or physiological peculiarity may be exhibited by the gills.

(The illustrations were taken from Dr. Carter's article in *Endeavour*, by permission of the Editor.)

Paludrine

THE loss of the Java cinchona plantations, principal source of the world's quinine, came at a time when it was necessary to maintain large armies in some of the world's worst malarious regions. Fortunately most of the details of mepacrine, the German synthetic antimalarial, were known and its large-scale production was immediately undertaken. Mepacrine is not, however, an ideal antimalarial; it turns the skin yellow, is difficult to manufacture, and has other disadvantages. Professor Warrington Yorke, of the Liverpool School of Tropical Medicine, was among those who saw clearly that malaria could be a factor severely limiting military strategy and it was largely as a result of his advice that Imperial Chemical Industries set up a malaria research unit. As a result of this unit's work—later it collaborated closely with the Liverpool School—a series of new antimalarials, of which paludrine is the most important, was discovered. Full details of this work have now been published in the December-January issue of the *Annals of Tropical Medicine and Parasitology*. (This number is dedicated to Warrington Yorke, whose untimely death—undoubtedly hastened by his unstinting war work—prevented him from seeing the fruits of his foresight and initiative.)

An ideal antimalarial drug must perform two distinct functions. It must be effective in controlling active attacks of malaria, which means in effect that it must attack the malaria parasite during the phase of its life cycle passed in the blood. A prophylactic effect is, however, equally desirable: the drug should attack the parasite in the interval, several days long, that occurs between its introduction into the body by the bite of an infected mosquito and its appearance in the blood, which causes the actual malarial attack. Quinine and mepacrine perform the first

[Continued on p. 89

Dr. Julian Huxley has been appointed executive secretary of the Preparatory Commission of UNESCO —the United Nations Educational, Scientific and Cultural Organisation. In this speech to the "Science and Welfare of Mankind" conference held in London last month he gave his personal views as to what things UNESCO might do. This article gives the salient points of that speech.

THE FUTURE OF UNESCO

JULIAN HUXLEY, F.R.S. D.Sc.

It is clear that a great deal of organisational thinking will be needed. What should be the relation of UNESCO with other organs of the United Nations? I do not know what is in the mind of the authorities, but I imagine that the primary relation will be with the Economic and Social Council and not with the Assembly; but it is clear that there must also be some sort of liaison with the Atomic Commission and the Security Council, and with the Trusteeship Council now that that has been set up. Clearly also there will have to be scientific and other liaison with the other special agencies which are being set up in relation to the Economic and Social Council —namely, the Food and Agriculture organisation, the ILO, the future health organisation and so on. Personally, I hope—I do not think it has been decided—that science will also be represented at the highest or Council level in the form of some small, high-powered scientific advisory committee to each of the three major Councils.

I understand that the view which is generally favoured is that there should be a number of major branches covering subjects. Obviously education will be one of these, and the scientific branch will be another, and the arts and letters another. I understand there is a suggestion that mass media of information, like radio, films, the Press, and so on, should constitute a fourth branch. It is not yet decided whether there shall be one scientific branch or two—one for the natural sciences and one for the social sciences. If it proves too complex to have them in one, I shall use all my efforts to see that there is some powerful liasion organisation between the two branches.

I hope very much that there will be a strong representation on UNESCO of the applied and industrial sciences, and that we shall not be highbrow and academic.

There will clearly be need to link the scientific section with the work of the other sections—letters, philosophy, music and the arts, education and mass media. One suggestion which has been made is that that should be done by a series of functional divisions dealing with practical problems such as libraries, museums, publications, abstracts, exchanges of personnel, textbooks and so forth.

There should obviously be one branch which would be the public relations branch of UNESCO itself, telling the world what it is doing and hopes to do, what information it hopes to get, and so on. In that science would clearly play a large part.

Another practical problem, before we come down to the more interesting theoretical problems, will be to secure the adhesion of the requisite number of nations to UNESCO. The most important of all those adhesions which we require is clearly that of Soviet Russia. It will also be important to obtain the adhesion, or at any rate the co-operation, as soon as possible, of certain neutral nations, of Sweden and Switzerland; and let us hope that soon there will be the possibility of securing that of Spain, and the adhesion of certain ex-enemy nations, of which Italy at once leaps to the mind.

Coming to the general question, so far as I have been able to consider the matter what seems to me to be the most important principle to bear in mind is this, that what UNESCO ought to try to do in relation to science is to get more science, more efficient science and better integrated science into world affairs.

Science and the scientific way of thought is as yet the one human activity which is truly universal. There is no single religious, aesthetic, or political way of thought which is as yet universal. We want, therefore, to encourage this universality of scientific thought and through it help to build the basis of general universalism.

When we come down to more specific matters, we perceive in the perspective of evolution that one of the things which has counted for much in the recent pre-human evolution of organisms has been better co-ordination at higher nervous levels, co-ordination of information and co-ordination of effective action. We want to translate that into the social level. In this connexion UNESCO could perform many valuable functions. It could take over certain of the functions of what H. G. Wells has often referred to as the World Brain. We want to speed up exchange of ideas. We want a far better system of exchange of what the Americans would call 'hot' scientific information—better abstracting systems, universalised, probably on micro-film, catalogued and sorted out by one of these highly ingenious devices such as Vannevar Bush worked out at the Massachusetts Institute of Technology. A very important item is an efficient translating service, especially now that countries like Russia, China and others are coming more and more into the scientific picture. We want the fostering of scientific gatherings, both of existing organisations and of new ones, both large international gatherings and small, special *ad hoc* gatherings to deal with particular borderline problems. We want exchanges of personnel, utilising all the latest methods of communication—for instance, taking leave from the Colonies by air in order to get as much time as possible in this country for refresher courses and so forth. And do not let us forget co-operation with regional schemes already in existence, such as those in West Africa and the Caribbean.

What seems particularly necessary is the levelling up —up, not down—of scientific activity in the less scientifically developed areas of the world, from China to Peru. An enormous amount of work needs to be done there

before we can say that the scientific butter is spread adequately thickly over the bread of the surface of the globe. At the moment there is a most unequal distribution. As long as scientists in these less developed areas are few and far between they will be isolated, and will not get the adequate stimulus to keep them excited about their own problems. Unless international organisations help them, very likely they will not have access to the best apparatus for their work.

Another thing that UNESCO might do is to make an investigation into the proportion of the national income which various countries spend on scientific research, pure and applied. That is a preliminary necessity for setting standards for scientific expenditure. When Governments perceive that other Governments are far ahead of them in such ways, perhaps they will begin to redouble their own efforts.

In general, one of the things that clearly must be aimed at from the point of view of world development is an increase of scientific personnel, in pure research, in university and school scientific teaching. Let us not forget that very important category of technical and laboratory assistants, an indispensable category of scientific workers.

There are only a limited number of people who are capable of distinguished work in science, and a rather larger number, but again not a majority, who are capable of really useful work in science. Do not let us forget that the inequality of man, both in quantitative and qualitative ways, is a fundamental fact of human nature, and that the variety of the human species is one of its great strengths. What we want to do is to find out scientifically how to make the best of that variety.

Possibly UNESCO might help to promote something like an international university. It is a very interesting idea, which has been mooted in certain quarters, that there might be such a university for the training not only of future international civil servants but also of anyone—scientists, politicians, technicians and so on—who might be called on to undertake work of an essentially international character.

Finally, UNESCO should stand, so far as it is possible for such an international organisation to do so, strongly against any idea of scientific secrecy.

UNESCO will obviously have its hands quite full enough, and it does not want to take on jobs which are already being done by other organisations. It wants to find out, and needs to find out, what other international scientific organisations are in the field, and to see what it can do to help them to co-ordinate their activities and so forth. Do not let us forget that there are a great many important scientific organisations in the field. There are the various international scientific congresses, the international scientific unions which are integrated already in an international council, and the special *ad hoc* international bodies like those conducting locust research.

Although in this field there are a great many existing bodies, there are also a great many gaps. I have been looking a little into the literature, and I find the rather remarkable fact that there appears to be no international organisation whatever covering the extremely important field of archaeology. It would be for UNESCO to make a survey of the fields of study and research in science and to endeavour to see that the gaps are filled. There are many other fields, such as soil erosion, certain aspects of tropical medicine, and anthropology, in which much remains to be organised.

One of the jobs of UNESCO, I imagine, would be to promote more general information concerning science, by adult education. It will have its own public relations section; it might possibly run its own journal. The scientific sections should permeate the other sections so far as they cover the field of information, the Press, films, and so on. It might help to promote another idea put forward by H. G. Wells, the idea of a World Encyclopaedia.

Personally, I hope that it would help to promote studies in scientific methodology; how, for instance, the methods worked out in one branch of natural science could be applied to another, or to the social sciences, or *vice versa*, the best methods of team work, the scientific study of planning techniques. Above all, I think that it is important to persuade Governments and authorities in general that every subject can be studied scientifically, including even a great many which at the moment are not treated or studied scientifically—population, its increase or decrease; eugenics; public opinion; linguistics, the whole question of the improvement of languages, the invention of new and auxiliary symbolic aids to language, the possibilities of an international language and so on.

There would be, perhaps, the possibility of undertaking what was suggested by the British Association Conference in 1941, the building up of an adequate natural resources survey for the whole world.

Another job which will face the infant—I suppose it is an infant, and not an embryo—UNESCO at this stage, is to consider what links should be set up between UNESCO as an international organisation and the various nations which are represented on it; and in particular, of course, that will concern this country. Should one seek to have a body nominated by the Government, or should it be set up to represent the various interests or what should it be? Probably there will be some sort of general cultural, educational and scientific office with its own staff, which would indirectly, though not directly, represent the various interests in the field of science—the Royal Society, the Association of Scientific Workers, the British Association, and the various Institutes and Societies.

His Majesty the King will open the Empire Scientific Conference being organised by the Royal Society. The Conference will be held in June and July and will be attended by prominent scientists from the United Kingdom, most of the Dominions, India and the Colonies. The primary purpose of the Conference is to provide an opportunity for an exchange of views upon scientific problems which are of immediate practical importance to various parts of the Empire, and to discuss ways and means of achieving the greatest practicable measure of collaboration between scientists in various parts of the Commonwealth in the solution of these problems. The Royal Society's Conference will be followed immediately by the Commonwealth Scientific Official Conference, which will discuss the detailed measures to be taken to organise and promote collaboration in scientific research throughout the Commonwealth.

Chemurgy—New Uses for Farm Crops

M. K. SCHWITZER, Ing.C. (Prague), A.M.I.Chem.E.

CHARACTERISTIC of our industrial age is the continuous search for new raw materials, and the opening up and development of resources hitherto unused or little used to appease the insatiable appetite of our factories. Before coal was used for power generation and before the present vast petroleum industry developed, most of the raw materials for manufacturing purposes were of vegetable or animal origin. (The exceptions were a few metallic ores and a few minerals like sand.) A century ago, over four-fifths of all products used by man came from the field or forest: today probably not more than a third (by weight) of all products used by man, inclusive of food and clothing, are of agricultural origin.

It would be a mistake to ascribe this change solely to the increased demand for food. Though, of course, food-growing is agriculture's first priority, it has also—together with forestry—the indisputable task of providing cotton, wool, rubber; tallow and oil for candles, soap, glycerine and plastics; hides for leather, bones for glue; wheat and potatoes for power alcohol and synthetic rubber; cellulose for explosives, films and lacquers; casein, soya beans, peanuts, egg white and other protein-containing matter for fibre manufacture. There are many other raw materials of agricultural origin, such as kapok, pyrethrum, sisal, oat hulls (husks), jute, cotton, wheat straw and bagasse, and from these are derived thousands of different manufactured products.

It is the task of chemurgy to apply the principles of chemical technology to the elaboration of agricultural products, thereby not only opening up new resources for industry but also adding a new value to the products of the farm and forest, bringing new crops into large-scale cultivation and thereby contributing to the prosperity of the farmer and the country. (Table I.)

Though agricultural products have served men since the beginnings of history, and though good use has long been made of chemurgic principles, the word '*chemurgy*' itself was coined as recently as 1934 by the American, Dr. William J. Hale, then research consultant to the Dow Chemical Corporation. The economic depression in the early thirties which hit American farmers hardest gave chemurgy a great impetus. In various parts of the United States desperate men got together to discuss with scientists and engineers the possibilities of using 'surplus' farm crops in industry. In May 1935, three hundred farmers, scientists and manufacturers met at Dearborn, in Michigan, to discuss how rural areas could be revitalised by new chemurgic industries. At first, attempts to do this were made independently in different parts of the country, but soon it became evident that it would be necessary to co-ordinate the efforts in order to avoid duplication of research. This was particularly necessary as there was little money available to finance the investigations. In 1938, President Roosevelt and Vice-President Wallace, the latter himself a farmer, reorganised the Department of Agriculture and created the Bureau of Agricultural Research and Technology which was to assist and guide what by that time had already developed into a powerful chemurgy movement. In the same year the Agricultural Adjustment Act was passed and regional laboratories for chemurgic research were created in Illinois, California, Louisiana and Pennsylvania. Each of these was staffed with about 200 research workers; a million dollars was appropriated annually by Congress to finance them. (One of the far-sighted men who voted for the Agricultural Adjustment Act was Senator Truman, then but little known outside the borders of his State, Missouri.)

Farm Products	1943 *Production*	*Estimated percentage used in process industries*
Maize	3,076,159,000 bushels	12
Wheat	836,298,000 ,,	5
Rye	57,673,000 ,,	10
Barley	322,187,000 ,,	20
Flax seed	52,008,000 ,,	95
Rice	70,025,000 ,,	3
Sorghums	103,168,000 ,,	5
Soya beans	195,762,000 ,,	90
Cotton seed	5,390,000 tons	80
Cotton linters	1,168,000 bales	90

TABLE I—FARM PRODUCTS USED IN THE UNITED STATES FOR PROCESS INDUSTRIES

The Rise of Chemurgy

To help the Federal Government in its great task of putting American agriculture back on its feet, scientific institutions and industrial companies expanded their research programmes in this branch of applied chemistry. From the beginning, industry was in close co-operation with the Government's regional laboratories. The Rackham Fund (one of the main sources of money for U.S. agricultural research) provided in 1937 half a million dollars to Michigan State College for chemurgic research. In 1939 Ohio's Governor, J. W. Bricker, established a Chemurgic Commission as part of the State's administration. The Massachusetts Institute of Technology made Dr. K. Taylor Compton its first chemurgist. By 1937 the National Farm Chemurgic Council, headed by Dr. H. Everett Barnard, had more than 1,600 individual members and 150 subscribing corporations each contributing 2,500 dollars a year. At North Texas State Teachers' College, G. C. Wilson conducted the first chemurgic classes. The Ford Motor Company's soya-bean research station developed a plastic as a basic material suitable for the production of certain parts for motor car bodies.

Dr. W. J. Hale's book, *Farm Chemurgic*, published in 1934, soon became the unofficial bible of the new movement. It was in this book that the word '*chemurgy*' was coined. The aim of the book was to show how to make the maximum use of agricultural products in the manufacture of consumption goods.

At the Dearborn meeting it was decided to hold an

FIG. 1.—Seeds contain proteins that can be converted into textile fibres. Those seen in this photograph (which was taken in an American factory) were prepared from soya beans. Soya-bean fibre is said to be as warm as wool, and can be made at a competitive price.

annual convention, each year in a different town, at which farmers could meet scientists and manufacturers to discuss problems of chemurgic interest. These have been a great success, and subjects as far apart as non-crystallising corn syrup and the 'farm-grown motor car' have been discussed. At a Texas meeting in December 1944, Secretary of Agriculture Claude R. Wickard emphasised the importance of further developing 'the related interests of agriculture and industry'.

Canada followed the example of her neighbour very early. The Canadian Chamber of Commerce formed a National Chemurgic Committee and Dr. W. D. McFarlane was commissioned to make "A Survey of Canadian Research on the Utilisation of Farm Products" which was published under this title in May 1941—an impressive work. In Australia the use of agricultural wastes, and scientific research in the wool industry are among the chemurgic subjects for which work is on hand.

China, too, has its counterpart of the chemurgy movement. It was recently announced that 17 laboratories, 10 model factories and 4 extension stations are finding new industrial uses for China's agricultural products. The manufacture of rubber and motor fuel from tung oil is a field on which Chinese chemurgists have concentrated their research with notable success. There are also some 140 distilleries in China, some of which are using molasses as raw materials, but the majority use kaoliang (grain sorghum) and other foodstuffs.

All over the world, farm crops have found their way into the factory. Many of the Red Army's combat vehicles were fitted with tyres made from Sovprene, a synthetic rubber derived from potato alcohol; a crimped textile fibre resembling wool was made by the Germans from wood; caffeelite is a plastic derived in Brazil from coffee—to give only a few examples.

Chemurgy and the British Empire

The British Empire is in a special position in respect to chemurgic development. While India, Burma, Ceylon, S. Africa and the colonies provide, of course, a vast and still almost untapped reservoir of wealth for their inhabitants, the British Isles are an import country for agricultural goods and a home chemurgic industry could be of only limited extent. Alcohol distillation from molasses is one of the older British chemurgic industries (though most of the raw material, it should be noted, has to be imported), while the manufacture of

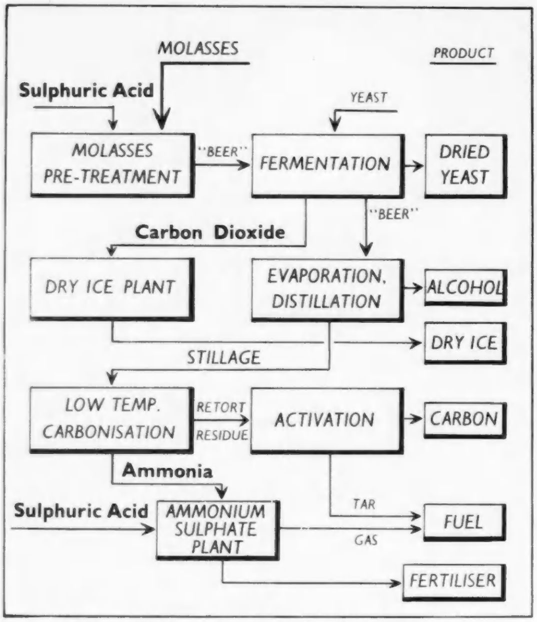


FIG. 2.—This flow sheet relates the processes involved in the modern alcohol plant described in the text. There are four important by-products, while further economy is achieved by using other by-products to heat the furnaces.

paper from straw, and seaweed utilisation, are two of the notable wartime developments.

Another wartime development is the new synthetic wool 'Ardil', made from peanut proteins (Fig. 3). Peanuts are grown in India and other places in the Empire, and their full utilisation exemplifies a promising case where the co-operation of different parts of the British Commonwealth could bring prosperity to all parties concerned. In India alone the area under peanuts, or groundnuts as they are also called, is about 6 million acres, producing each year nearly $2\frac{1}{2}$ million tons of unshelled groundnuts. Groundnuts consist of 24-26% hulls (husks), 33-36% of oil and 40-42% of protein-containing cake. While the edible oil is used both locally and for export—for making 'vegetable ghee' and margarine respectively—the hulls have found hardly any use except for burning under boilers. The residual cake after oil expression or extraction is, on the other hand, a valuable highly nutritive cattle food. It contains about 45% recoverable proteins, or about 450,000 tons of useful proteins are available in India annually. This is a tremendous reservoir of wealth. The quantities used for the manufacture of the synthetic wool 'Ardil' are at the moment, of course, only a fraction of the above figure. A certain amount of cake will not become available for chemurgic purposes since it will have to be used as heretofore as a cattle food to support milk and meat production.

Chemurgic developments in the British Empire have been few so far, but investigations holding promise for the future have been started by the Colonial Products Research Council, which was set up during the war. The council's research director is, as one would expect, an organic chemist, Professor J. L. Simonsen; organic chemistry is well represented on the Council, whose members include Sir Robert Robinson, Professor W. N. Haworth and Sir I. M. Heilbron. At the time the Council was established there were few scientists who could be spared from wartime research to devote attention to finding possible new uses for colonial products, but in spite of this difficulty a start has been made and the latest annual report—the Council's second, published in the document *Colonial Research* 1944-45 (Stationery Office, Cmd. 6663)—states that research is in progress on citrus products, clove oil, ergosterol, sugar, starch, cocoa, timber vegetable oils, camphor oil, sisal and pyrethrum.

Chemurgy and the War

By the time the United States entered World War II, farm chemurgic industries had become already part and parcel of the American economic structure. This was one of the reasons why the U.S. was able to implement its gigantic synthetic rubber programme. It was in another book of Dr. Hale's, *Prosperity Beckons*, that attention was drawn to the great importance of an alcohol industry, not only from the point of view of using alcohol as fuel in internal combustion engines but as a basis for manufacturing a wide range of chemical products. After Pearl Harbour the United Nations were deprived of natural rubber. The Baruch Committee set up by the U.S. War Production Board recommended that out of the total output of 845,000 tons of synthetic rubber needed to meet the annual requirements about a third should be produced from grain alcohol, the remainder to come from the petroleum industry. When the latter's capacity was taxed to the limit by the rapidly increasing demand for high-octane aviation petrol, it was decided to increase still further the share of chemurgic rubber in the synthetic rubber programme. When the U.S. Rubber Director was able to announce that the American farmer had fulfilled the nation's demands for alcohol needed by the synthetic rubber industry, chemurgy had its greatest triumph.

The story of power alcohol and synthetic rubber has been told in much detail (readers are referred to the article on synthetic rubber in DISCOVERY, 1944, Vol. V, p. 72; power alcohol was dealt with in Colman Green's survey of industrial fermentations, DISCOVERY, 1944, Vol. V, p. 370), but it is worth referring to one or two points which are indicative of the line chemurgic research is taking. There is, for instance, one alcohol plant in the process of erection which uses molasses—a by-product of sugar-cane mills—as a source of alcohol. Now there is nothing exceptional in this, but what is new is the complete utilisation of all the by-products (Fig. 2). The yeast from the fermenters is separated by centrifugal separators from the fermented liquor—'the beer'—and dried to give a protein concentrate suitable for human consumption. After further treatment of 'the beer', a concentrated residue—'the stillage'—is obtained which hitherto found practically no industrial use. In the new plant it is carbonised in low-temperature retorts; the gas from the retorts passes through towers that extract the tar, and this tar is used as fuel for the furnaces. The residue from the retorts yields carbon, of high adsorptive qualities and an effective decolorising

agent; the residue also yields a most valuable potash fertiliser. The gas also contains considerable quantities of ammonia, and by treating it with sulphuric acid the valuable fertiliser, ammonium sulphate, is produced. The gas that is left after these processes has a high calorific value, and is used for heating the furnaces.

A further by-product, the carbon dioxide from the molasses fermenters, is converted into 'dry ice' blocks. ('Dry ice' is solid carbon dioxide). Thus it is seen that this fermentation plant will, in addition to its main product, power alcohol, produce edible yeast, valuable fertilisers to be returned to soil (to grow more food and more chemurgic raw materials), and important industrial materials such as decolorising carbon and 'dry ice'—the last-named will be valuable to the farmer for refrigeration purposes.

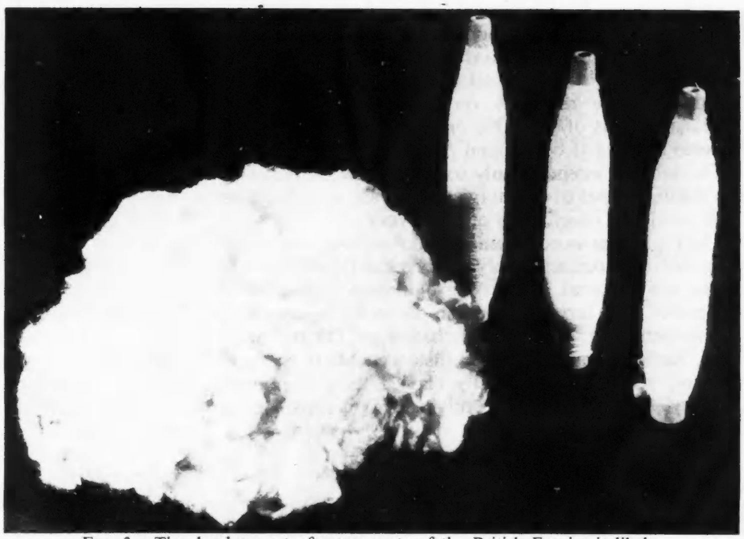


FIG. 3.—The development of many parts of the British Empire is likely to be affected by progress in chemurgy. For instance, peanuts, one of the Empire's staple crops, can become an important source of synthetic textiles. 'Ardil' is an example of such a textile fibre; 500 pounds of it can be made from a ton of peanuts, and it is likely to be cheaper than wool. A 50% 'Ardil'/50% wool mixture is hardly distinguishable from pure wool.

Part of the heat required for running this new plant will come from combustion of its own by-products. There will be no waste as in most previous distilleries. The high market value of the by-products will have the result of cheapening the power-alcohol production costs.

A plant with great interest for the chemurgic chemist is the Jerusalem artichoke. This plant can be grown almost anywhere and gives good yields even on gravelly soil. It is grown on a large scale in France, Italy, the United States and China. The carbohydrate content of the potato-like tubers is about 30%. Since one acre of Jerusalem artichokes yields about 28 tons of tubers under average conditions and 1 ton of tubers yields some 19 gallons of alcohol, it is not surprising to hear that during the recent war, when France was suffering from a severe shortage of motor fuel, ten distilleries based on Jerusalem artichoke tubers were operated in that country. The stalks of the plant also have been used for alcohol production. The residue from the process is a valuable cattle food containing 22-25% protein. Experiments have been made to find out whether it would be a practical proposition to ferment artichoke tops to obtain methane for use as fuel gas.

The fermentation of farm wastes is altogether a fascinating subject. In this direction very little has been done so far, which is surprising considering the millions of tons of wheat straw, corn cobs, flax-straw, peanut hulls, rice hulls, oat hulls, leaf waste, potato haulms, etc. which could be annually used for fuel and power gas production. (Of course, all these farm wastes are at present not just thrown away or burnt. The bulk of them are returned to the soil and, though they have little fertiliser value, they help to build up humus in the soil. Some use has also been made, for instance, of straw for paper making, but the tonnage involved is small. Oat hulls, too, have found their way into the factory; from them the valuable chemical compound, furfural, is derived, which plays an important role in petroleum refining, and can be condensed with phenol to give a synthetic resin similar to bakelite.)

It will be gathered that chemurgic industries are potentially based on almost any plant that can be grown on a large scale and of which the harvesting and transportation are technically feasible. Three main groups of chemurgic industries are distinguishable, based on the relative food value of their raw materials for man. The adjoining table represents an attempt to provide such a classification. The first group of chemurgic industries draws its raw materials from plants or animals that also provide food for man. The second group is based on plants which are definitely not edible and are cultivated for industrial

TABLE II—CLASSIFICATION OF CHEMURGIC INDUSTRIES

Chemurgic Industries Based on Materials that also Provide Food	*Chemurgic Industries Based on Materials Exclusively used for Chemical Processing*	*Chemurgic Industries Based on Waste Materials, Weeds, etc.*
VEGETABLE AND ANIMAL OILS—Soap, glycerine, plastics, paints MILK—Casein plastics, adhesives, pharmaceuticals GRAIN—Power alcohol, synthetic rubber, 'dry ice', acetone, starch, lactic acid	WOOD PULP—Alcohol, plastics, turpentine, rayon, paper TREE STUMPS, ETC.—Acetic acid, charcoal, tar, pine oil, rosin SEAWEEDS—Alginate rayon	SAWDUST—Explosives, linoleum, plastic mouldings HOOFS, HORNS, OFFAL, BONES—Gelatine, glue, fertilisers MILKWEED—Insulating felt, rayon, chewing gum OAT HULLS—Furfural

utilisation only. (It is often not easy to draw a line here; for instance, cotton is an industrial plant, yet cottonseed oil is used by the thousand tons for margarine production.) The third group comprises all those industries which are based on 'waste' materials, on by-products, weeds and similar materials of vegetable or animal origin for which hitherto no use has been found.

The table is intended only to give a few examples of the different types of chemurgic industries; an exhaustive table would fill many pages of DISCOVERY.

The use of the word 'chemurgy' throughout this article is limited to processes involving chemical transformation of the raw material. Processing of natural rubber, flax, sheepwool, jute, turpentine and so on does not, according to this definition, come under chemurgy. On the other hand, leather manufacture, for instance, entails chemical changes, yet it is not usually classed as a chemurgic industry. The difficulties of evolving a rigid classification are obvious.

Oils and Fats

A moment's thought about the items in the first column of the table brings the realisation that food markets and chemurgic industries may be in competition for supplies. During the war the provision of grain for synthetic rubber production without breaking into food reserves must have considerably exercised the U.S. Government departments concerned, whose problem stands as an example of this kind of competition. The present food crisis has caused a sharp reaction in the U.S.A. and a great deal less grain will go into alcohol production and other industrial uses. Oils and fats give us another good illustration. The distribution of all kinds of oils and fats needed for manifold purposes was strictly controlled in Britain during the war, and also on the Continent and in the United States. Today, when we are faced with a world shortage of oils and fats, the control seems likely to remain for a long time.

The largest industrial consumers of fatty materials are the food and soap industries. The manufacture of margarine and shortening, which takes a large proportion of the raw materials, utilises groundnut oil, coconut-, palm-, palm kernel-, cottonseed- and whale-oils; several other oils —soyabean, sunflower, rapeseed and sesame—are also used. In margarine manufacture the extracted oil is hardened by a catalytic process that adds hydrogen to the unsaturated compounds present in the oil. (An account of margarine production appeared in DISCOVERY, July 1944, Vol. V, p. 196.)

Some of the oils mentioned above have been used for a long time in the soap industry in addition to animal tallow. Household soap, toilet soap, liquid soap, soap flakes, scouring powders, shampoos and similar products are obtained by 'boiling' mixtures of tallow and vegetable oils with alkalies, while the glycerine that separates out is purified, concentrated and used in the preparation of explosives, plastics, pharmaceutical preparations, etc. Treated with sulphuric acid, castor oil yields 'Turkey red oil', used in dyeing textiles and for other purposes. In a polymerised or dehydrated form it finds increasing use in paint and varnish making. The main application of the drying and semi-drying oils—such as tung, oiticica, linseed- and cottonseed-oils—lies in the manufacture of paints and varnishes, but some of them are also used for making margarine, though the hardening process involved makes them rather expensive for this purpose.

Despite the wide variety and great importance of the products already derived from natural fats, research is still proceeding at a rapid rate. Chemurgists expect to obtain many new products from fats, which are considered to form one of the most fruitful fields for chemurgic research. Because they cover a wide range of saturated and unsaturated hydrocarbons with both short and long chains they may become an important source of raw materials for the chemical industry. For their variety, the products from oils may come to compete with the products of petroleum refining. So far about 4,000 vegetable oils, fats and waxes are known, yet only a small proportion of these have been employed for human food or for chemurgic industries. Perhaps vegetable oil will come eventually to stand as high as mineral oil on the agenda of international negotiations.

Two weeds, which illustrate the third category in the table, deserve to be discussed, not because they are utilised in very large quantities, but because of the variety of their products and the potential new uses they may serve.

Finding Uses for Weeds

In 1933, Dr. Berkman, a Russian physician and scientist working in America, started chemurgic researches on milkweed. There are many species of milkweed, of which forty grow in North America alone, from which he and his co-workers had to choose. Finally it was found that the common milkweed, *Asclepias syriaca*, was most suitable. This is an erect perennial weed, 2-5 ft. tall, from which seeds bearing long silky fibres are collected in autumn. When the Japanese occupation of the East Indies cut off supplies of kapok—used for stuffing life-jackets as well as mattresses and cushions—the silky floss of milkweed became a valuable substitute. The buoyancy of the floss is as good as kapok and six times better than that of cork; a life-jacket which contains 3 lb. of floss will support a man for four days in water. It is warmer and lighter than wool. If the floss is first soaked in a dewaxing solution, then washed and agitated in a colloidal adhesive solution of latex rubber, an insulating felt is obtained. The milkweed, however, has more surprises in store. Its leaves and stem contain 1-4% 'rubber'. Last year a pilot plant was erected and a milkweed 'rubber' obtained which, when mixed with Buna S synthetic rubber, gave a product of increased tear-resistance and flex life, though tensile strength was reduced. Other uses are indicated in Fig. 4. Like many successful weeds, it will thrive on poor soil, and is immune against insect attack. If it maintains its promise, it will soon cease to be a weed.

During the war a job has been found for yet another weed. The water-hyacinth (*Eichhornia crassipes*), which has very decorative mauve flowers, is a pest in Bengal and other parts of India where it clogs the waterways, killing off fish and upsetting river transport. The Indians call it the 'Lilac Devil'. Masses of it have been netted and towed out to sea; looms have been constructed in rivers to check its spread. Crushing the plants between rollers mounted on barges has been tried. Owners of

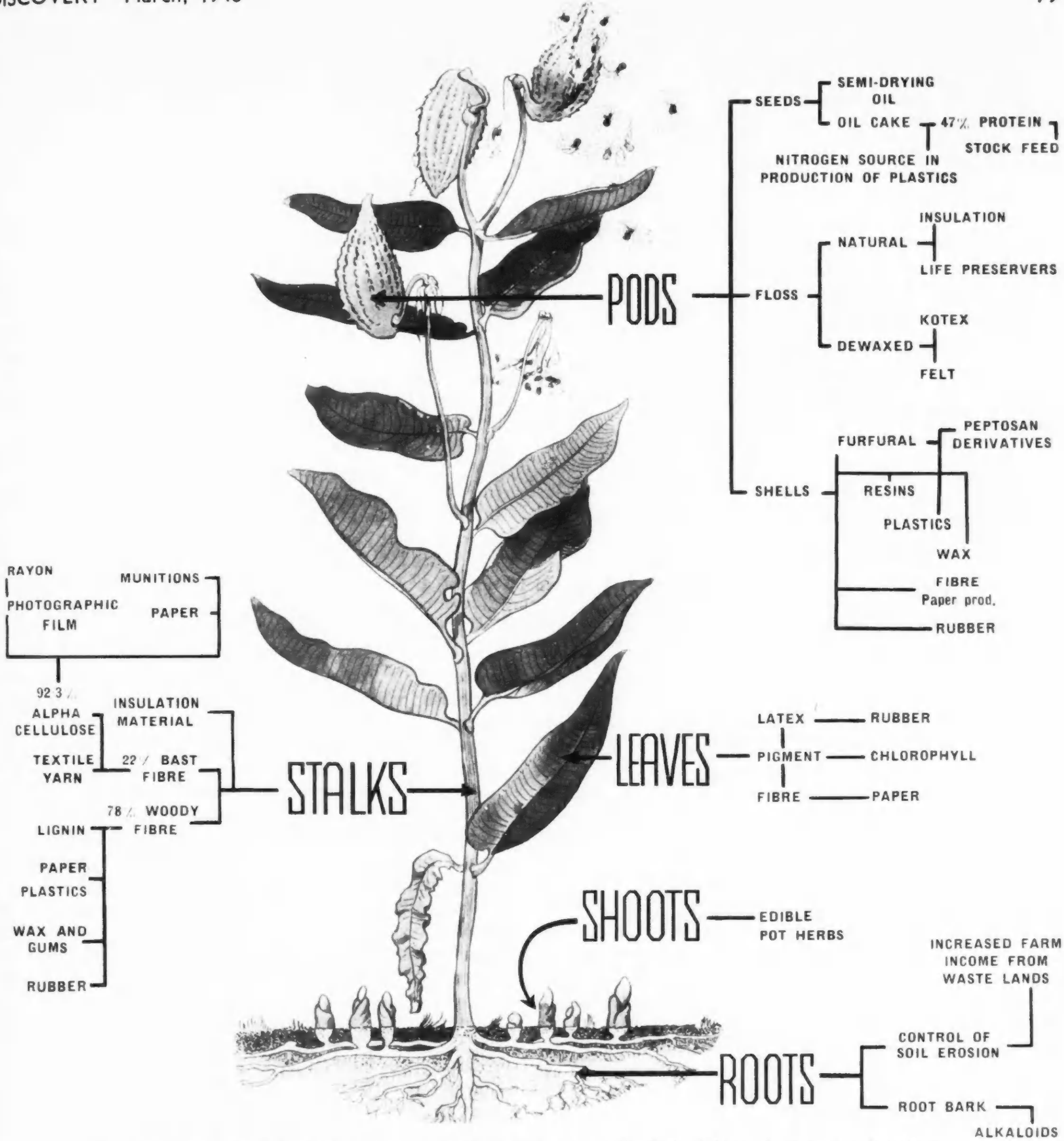


FIG. 4.—This diagram indicates the range of products that can be derived from the common American milkweed. During the war it provided a valuable substitute for kapok; 'rubber' has also been extracted from milkweed on an experimental scale.

ponds have been compelled by legislation to destroy the weed. The Administration set up an expensive experimental factory with the aim of extracting potash salts from the collected weed. But not until 1938 did the Department of Industries hit upon a successful line of attack. The Department found a way of utilising it in the manufacture of plastics; the process which has been worked out and patented is said to be simple and cheap, a company has been set up to develop it and the products are said to be in demand. The money derived from this industrial use more than pays for the cost of collecting the weed.

Seaweed

In one respect the processing of seaweed to produce, for example, seaweed rayon does not fit into the chemurgic picture, but to separate off the industrial utilisation of seaweed from chemurgy is, I think, to make too much of the fact that it is not grown on land. (Seaweed is already 'farmed' in the sense that it is cultivated, and the practice of cultivating it rather than leaving its growth to nature's care is likely to be extended in the future.) So far as Britain is concerned, very little seaweed is eaten. For

FIG. 5.—Noreplast is a thermosetting plastic developed by one of the U.S. Regional Laboratories that are devoted to chemurgic research. Farm wastes, such as corn stalks, enter into the manufacture of Noreplast articles, of which a selection is shown here.

that reason, I have placed seaweed in the second category of Table II.

In the tidal zones of the Atlantic-Pacific oceans, especially on the coasts of China and Japan, seaweed has been used for centuries as food. In the Far East it is actually cultivated; some of the seaweed farms are at considerable depths below the surface, and diving equipment has to be used for tending the crop. Its use as a fertiliser is equally old and still accounts for the largest part of seaweed consumption. Before the advent of the Leblanc system of soda manufacture in the middle of the last century, brown seaweed of the various species of the wracks, in particular Black Wrack and Bladder Wrack (*Fucus vesiculosus*) were the chief sources of alkali, known as kelp, and many Irish and Scottish landlords derived large incomes from royalties received from kelp makers. Later it served as a source of iodine until, in about 1930, iodine obtained as a by-product in the crystallisation of Chilean nitrate definitely replaced kelp in almost all countries.

It is interesting to recall that during the first world war a giant seaweed of California, *Macrocystis pyrifera*, which grows up to 100 ft. long, was submitted to a unique fermentation process to obtain much needed acetone. This process was, however, abandoned soon after and today the chemurgic importance of seaweed lies on a different field.

The recovery of seaweed as a source of industrial products is of particular interest to Britain, for it was the English chemist, E. C. Stanford, who in 1883 reported to a meeting of the Royal Society of Arts chaired by Dr. Perkin that he had discovered a remarkable substance by soaking the fronds of brown seaweed. On acidulation a gelatinous mass separates out; this is alginic acid. While higher plants are built up from cellulose and lignin, seaweed cell walls are composed of various mucilaginous and gelifying substances of which alginic acid is one. Cellulose plays only a small part in the composition of the walls. Fucoidin is another such component; this is a gum which forms an exceedingly viscous solution in water. A third substance, laminarin, forms the reserve carbohydrate of the brown seaweeds.

Commercially, attention is focused today on both the brown and red seaweeds. By tonnage, the former are the more important; they yield algin. It is used in ice cream to impart a smooth texture. It is also used extensively in the preparation of cakes, jellies, icings, whipped cream and chocolate milk. Algin has one important use in the rubber industry. It is also useful for preventing the formation of scale in boilers; it finds another application in making dental impressions and provides a protecting cover for dentures made of acrylic resin. It serves in pharmaceutical and cosmetic preparations, is employed as a sizing material for cloth and as a waterproofing material, and also serves in the preparation of insecticides, storage battery varnishes, can-sealing compounds, etc.

A very important development of recent years is the production of rayon from alginic acid. The first seaweed rayon was prepared from a 5% solution of sodium alginate, and spun in a similar way to viscose rayon. Since then the technique has considerably improved and today seaweed rayon can be made, based on calcium alginate, which is cheap and easily spun and possesses satisfactory elastic properties for weaving and knitting. Alginate rayon has a rather high density (1·78) when dry. It can be dyed with selected direct dyes. There is, therefore, good reason to believe that the seaweed rayons will find an important place in the textile industry of the future. It is totally noninflammable. This fact led to its use in connexion with the camouflage of guns; it was found to be unaffected by gun flash.

Will chemurgy bring industry back to the point of deriving the greater part of its raw materials from agriculture? There seems to be little chance of this happening in the immediate future, but there is a clear indication that an ever increasing flow of agricultural crops will find its way into the factory. The great advantage of agricultural raw materials is that they are reproducible while coal and oil and ores will one day be exhausted, though that time may be remote. A further advantage is the possibility of cultivating the right type of crop for a specific purpose. The impact of an intensive chemurgic industry, apart from the purely industrial and economic effect, on the life of a nation is manifold. The prosperity of the farmer, the planning of rural communities, the easing of urban congestion, the health of the people—all these are aspects which must be taken into account when considering the development of chemurgy.

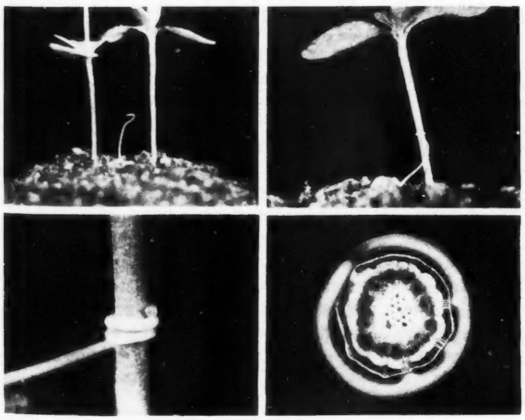
Percy Smith:
Pioneer of Cinebiology

It was H. G. Wells who said that the man of science was the only man who had something to say, and who did not know how to say it. In the field of visual exposition also, men of science have had much to show, and had hardly begun to show it, until Percy Smith (who died last year) brought living things to life on the cinema screen.

The London Scientific Film Society recently honoured his memory by the presentation of a programme of his films, introduced to the audience by Mr. Bruce Woolfe, who traced Percy Smith's career in cinébiology, and his achievement as the pioneer and the outstanding British figure in this field. The programme itself was a balanced compilation, chosen to illustrate his creative range in cinematographic technique as applied to biology and to express within the space of an hour the successive phases in Smith's professional achievement. (Other scientific societies proposing similar memorial shows can book this block of films through the Scientific Film Association.)

The first film shown was an anthropomorphic fantasy —*Archie the Ant—Episode II: The Tale of a Tendril;* Smith himself, in a letter to the National Film Library, has called it, with characteristic modesty, a 'travesty'. It is a charming fairy story of Bertie the Beetle, who takes a tendril from a plant in an imitation of the butterfly's proboscis and adapts it as a weapon to attack the Bogie Bug. Archie the Ant prances through the performance, and exults in the capture of the Bogie Bug in a spider's web. But Smith soon leaves fantasy—this was an undoubted loss to the ciné cartoon world—and *The Story of a Glass of Water* (British Instructional, 1927; silent) is a serious study in the microscopy of fresh water; it shows movements of algae, protozoa, and diatoms.

A lighter touch is displayed in *The Strangler* (British Instruction, 1930; sound), which exhibits superbly by, the Smith technique in time-lapse photography, the germination of dodder seedlings, their circumnutation in search

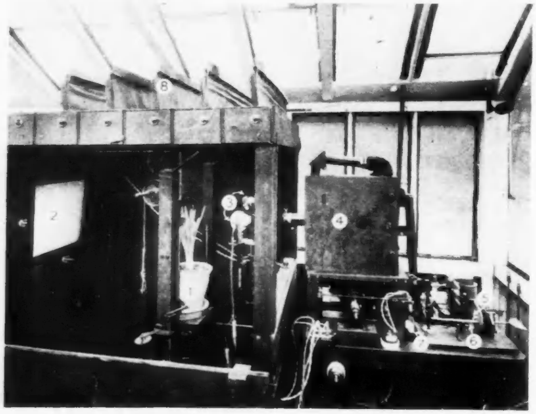


Four frames from *The Strangler*, the classic film of the dodder's life history.

of a flax plant, and the subsequent decay of the dodder's own roots, once it has obtained a nutritive hold upon the unwilling host. It is difficult to avoid being teleological when these plant mechanisms in the struggle for existence are thus displayed on a time-scale appropriate to the subject. Smith's work in the zoological field was exemplified by *The Development of the Chick* (Gaumont British Instructional, 1936; sound), a study in avian embryology from blastula to hatching, made under the supervision of Dr. Julian Huxley.

The last film in the programme, *Old Blue* (The Lupin, Gaumont British Instructional, 1939; sound, Dufaycolour), is at once a charming floral study and an elementary appetiser to the study of the complexities of Mendelian colour inheritance.

Before these films were shown, Mr. Bruce Woolfe spoke about Percy Smith's interesting life. Percy Smith was a man with a hobby, a hobby that became his life's work. At the age of 16 he became a clerk with the then Board of Education, with whom he remained until 1910; it is ironic that he did not in his time know how effectively his work was to be applied in visual education. His hobby first took form as lantern slides, which attracted the attention of Charles Urban, who was making a series of films under the general title, *The World before your Eyes.* In 1908 Smith undertook part-time work for Urban, and within a year he had made thirteen trick and zoological films. (In the following year Urban's Kinetofilm Company issued a catalogue of scientific and instructional films with 2000 titles.) Smith's first film, on the performance of flies, excited public interest; his success led him into biological fields, and he satisfied his keen interest in botany by designing in 1910 his first machine for filming plant life by time-lapse photography. His *Birth of a Flower* in Kinemacolour was an instant public success.



This is the apparatus Percy Smith contrived for his time-lapse work. The camera (4), an ancient Urban Bioscope model, exposes single frames; the interval between exposures is arranged mechanically. At each 'take', the shutters (8) are closed to shut out daylight, the subject (1) is illuminated by lamps (3) and photographed against an illuminated background (2).

He then left the Board of Education; his hobby and his occupation were clearly divergent and his 14 years of service had not brought them into alignment. Smith continued to develop his experimental flair, and at one time used ciné film with polarised light (which is again being tried). In the decade to follow, he made a large number of films for Urban and for the Naval Air Service, to which he was attached during the 1914 war. Unfortunately, none of his films made prior to 1923 with Urban can be traced, but it is safe to call this decade or so his period of experiment and invention.

Meanwhile, Mr. Bruce Woolfe had founded British Instructional Films and in 1919 the 'Secrets of Nature' films series was started. Some years later Smith and Miss Mary Field joined him, and the most famous triumvirate in the field of British non-theatrical film was formed. It is not possible to overestimate the contribution to cinematography, to science, to visual exposition and to British prestige made by this happy conjunction of personalities. This was a period of world post-war depression, and a period in which film technique changed from silent to sound film. Yet this was the time when *The Strangler*, *Climbing Plants*, *Seed Dispersal*, *How Plants Feed*, the beautiful *Life-history of the Fern* and many others of this calibre were produced. For Smith, it was a period of consolidation in the technicalities of his craft, and of specific contribution to visual exposition of the factual in science; it involved the expert collaboration of scientists and scientific institutions.

In the nineteen-thirties Bruce Woolfe, Mary Field and Percy Smith joined Gaumont British Instructional and the 'Secrets of Life' films were started on a five-year production plan. A succession of scientific films of a more didactic character was made under the supervision of men of eminence—Dr. Julian Huxley, Sir Edward Salisbury (now Director of the Royal Botanic Gardens, Kew), Dr. H. R. Hewer, and Professor Leiper. This was a period of real achievement, and brought into being a library of scientific films which was to be a source of knowledge for the student, and a basis for scientific film shows, club programmes, and indeed also of theatrical shows of popular science; *The Thistle*, *The Dandelion*, and, just before the recent war, Dufaycolour films such as *Old Blue* belong to this period.

During the war years, when studio space and film stock were restricted, his films were made under the aegis of the British Council. They included *The Onion*, *The Newt* and *The Maize*. His last film, *Pin-Mould*, was made for the British Council in 1943, under the supervision of Dr. B. Barnes.

Percy Smith died in March 1945. Through thirty years Smith canalised, via the medium of the film, his own particular aptitudes. He was a brilliant photographer, a keen microscopist, an ardent naturalist, and an excellent botanist. His inventiveness displayed itself in his early insect cartoon films (such as *Archie the Ant*), made with hundreds of cut-outs with interchangeable legs and heads; and later in his devices for time-lapse photography of plants and for photographing organisms under water, and roots in soil. Nor must one forget the deft humour with which he leavened his science without cheapening it.

His very human approach invested his films with a universal appeal. For example, the rootlet in *Roots* which shrivelled near the copper cylinder in the soil engenders a pleased wonder in the adolescent and an anthropomorphic reflectiveness in the philosopher, besides providing the plant physiologist with an impressive demonstration of the toxicity of metallic ions.

Smith's achievement was, first and foremost, the use of ciné film as a serious vehicle for the exposition of science, in the theatre, the schoolroom, the lecture room. It is the greater regret that he did not live to see his technique developed within scientific circles as a laboratory tool and a record of research. His photographic studies of climbing plants are accurate records of circumnutation, and would have lent themselves to precise time measurements of the translation in space of the stem tip, and hence to accurate mathematical analysis of this phenomenon. Or again, his ciné photographs of pollen tube germination would have permitted of accurate quantitative studies of the direction and rate of protoplasmic streaming, comparable with photographic methods of recording the apparent motions of the stars. Similarly, the particular methods of locomotion of the diatoms and the movement in *Spirogyra* (which are recorded in *The Filter*, *Story of a Glass of Water*) could with profit have been studied by the algologist and biophysicist.

The brilliant achievements of Bruce Woolfe, Mary Field and Percy Smith were founded on Smith's inventive mechanical ingenuity and his ardour for the world of living things. It was accomplished in the ordinary way of film business, without official grants from public funds or from educational scientific or other professional bodies; but it evoked the reward of scientific admiration in Britain, and the more specific gain of medals and awards at Brussels, Venice and Rome, a tribute to Percy Smith's contribution to the international standing of cinébiology in Britain.

BLODWEN LLOYD, M.Sc., Ph.D.

(By arrangement with the Scientific Film Association, who have provided us with this article in place of the usual monthly scientific film review.)

The Colouration of Fishes

CHAPMAN PINCHER, B.Sc.

THERE are no fishes that are totally without pigment. All have red haemoglobin in the blood, but some species, especially in the larval stage, give the impression of colourless transparency. Others, such as the fishes that live in caves, are plain white on the surface, though these are usually pigmented internally. There are also albino specimens of normally coloured forms. But the great majority of fishes are richly coloured, generally in a complicated manner.

Fish Pigments

Fish colour is mainly the effect of pigments contained in minute corpuscles. These are scattered, for the most part, in the surface layers of the skin, though in a few forms the visible colouration is internal, showing through the transparent skin and muscles.

There are three types of colour corpuscle—melanin corpuscles, chromo-corpuscles and guanin corpuscles.

The melanin corpuscles are transparent sacs containing granules of the black compound, melanin, which has the chemical formula, $(C_8H_7O_3N)_n$. Each corpuscle is connected by two small nerves, one connected with the spinal cord and the other with the sympathetic chain.

Chromo-corpuscles, which vary from red to light yellow, contain two pigments, carotene ($C_{40}H_{56}$) and xanthophyll ($C_{40}H_{56}O_2$). These are essentially plant pigments and fishes seem to derive their supply of them from the vegetation they eat, though sea-fishes can synthesise xanthophyll from carotene. If carotene is lacking in the diet, the yellow and red colours disappear from a fish's skin—the chief reason for the paling of fish kept in aquaria. Chromo-corpuscles in the gurnard and paradise fish (*Macropodus opercularis*), and probably in all species, have a nerve supply like the melanin corpuscles.

Guanin, which has the chemical constitution, $C_5H_5N_5O$, is a crystalline excretory product found in the skin, the scales, the silver layer of the eye and the swim bladder. The crystals may be free, but in the skin are usually contained in separate corpuscles. These have no nerves.

Other skin pigments do occur, but are very uncommon. The blue parrot-fish (*Scorus vetula*) has a definite blue pigment free in its skin: the green moray owes its colour to a superficial slime. Some fishes have only one type of corpuscle e.g. the catfish (*Amieurus nebulosus*) which has only melanin, but more commonly all types are present.

On the belly the guanin corpuscles form a solid layer and reflect light in a simple manner, giving a chalky appearance. On the backs and sides they are not so tightly packed and they produce an irridescent effect due to optical interference. The brilliant blue of the coral fish *Thalassoma bifasciatus*, for example, is entirely due to this: so is the metallic sheen of the roach. In the killifish, different degrees of optical interference may cause green, red, orange, and yellow effects. Guanin is responsible for the flash of a turning fish; this is a disadvantage, especially to a wounded specimen which, as a result of faulty balance, makes a series of flashes. Spoon baits and many salmon flies seem to be effective purely by their intermittent flash resembling a wounded fish.

Colour corpuscles in different concentrations and arrangements produce diverse effects. A mixture of black and yellow gives the back of the mackerel its characteristic green. Red, black and yellow corpuscles produce the brilliant colouration of the trout. The sea-robin and the breeding male stickleback owe their redness to masses of chromo-corpuscles.

Counter Shading and Disruptive Colours

In surface-feeding fishes, the pigment is usually concentrated on the back, gradually shading off at the sides to a white undersurface. This *obliterative shading*, as it is called, has great protective value, affording camouflage from fish-eating birds above and from predatory animals below. In one fish (*Coralliozetus*) with a transparent skin, obliterative shading is provided by the pigmentation of the gut membranes. Many fishes have the pigment irregularly distributed and a striped or patchy colouration results. This is called *disruptive colouration*, and is seen in its simplest form in transparent larvae, where a few dispersed black granules break up the general outline (Fig. 1). Weed-frequenting species like the perch, pike and angel fish, gain some measure of protection from their vertical stripes (Fig. 2). Mimicry is exhibited by the leaf-fish of the Amazon tributaries, which has a form and colour very much like a dead leaf—it even adopts the same drifting attitude. Some harmless fishes resemble poisonous or otherwise dangerous forms and are said to mimic them.

The general colour pattern of a fish species is usually fairly constant under constant environmental conditions,

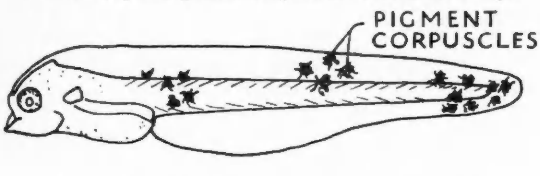


FIG. 1.—Larval whiting with a few scattered pigment granules breaking the outline.

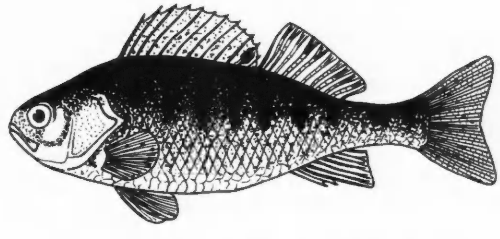


FIG. 2.—Perch, showing vertical striping; an example of disruptive colouration.

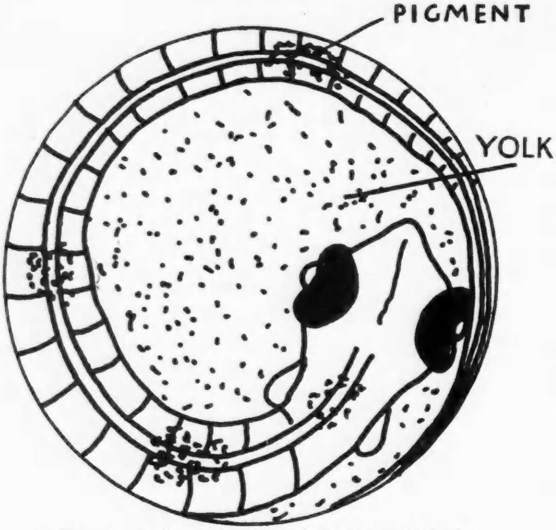


FIG. 3.—Cod's egg showing melanin corpuscles in the embryo.

but this does not apply to some tropical forms. The very differently coloured leopard grouper and golden grouper, for example, are but different varieties of the same species.

A few kinds show permanent colour differences between the sexes. Thus the male dragonet is always more brilliantly coloured than the female. The female millions fish (*Girardinus poeciloides*) is always uniformly greyish green. The males are of two distinct types, one with red spots on the dorsal fin and the other with yellow. The first pigment corpuscles—usually containing melanin—are laid down as a rule whilst the embryo is still within the egg (Fig. 3). In the killifish their position is conditioned by oxygen supply—the pigment cells arranging themselves along the blood vessels of the yolk sac. Whatever the mode of control in other fishes, the pigment pattern of the young hatched fish is a feature of the species. Thus the young larvae of the cod and pollack, otherwise very much alike, may be distinguished by the way the pigment pattern develops.

In many species the pigment seems to be formed by a direct response to light. The belly, receiving the least light, develops no pigment except guanin; the back, which receives most, is darkest. The Nile catfish, which swims upside down, has the pigmentation reversed (Fig. 4). The remora, which for the greater part of its life is attached by a sucker to a shark, does not always present the same surface to the incident light, and it is not obliteratively shaded, although it is a surface form.

The early drifting stage of flat-fishes is usually pigmented slightly on both sides, but when the larvae pass to the bottom-feeding stage and begin to lie exclusively on one side, the pigment gradually disappears from this blind side. If this surface is artificially illuminated, however, pigment develops there.

Young plaice kept in the dark develop no chromocorpuscles. Cave fishes are normally uncoloured but develop some pigment if exposed to light. Internal pigment, the dark colouring of deep sea fishes and the occasional capture of flat-fishes coloured on both sides are unexplained by the incident light theory.

Changes of Colour Pattern

Changes of colour pattern in fishes are associated with environment, emotion, production and age. The ability of fishes to change colour with resulting adaptation to background is backed by an imposing amount of laboratory work. Such changes may be classed as *defensive*, in that they afford protection from enemies; or *aggressive* as they allow prey to be captured more easily. In many fishes both interpretations hold. The extent to which different backgrounds can be 'copied' is limited by the number and distribution of the colour corpuscles in a given specimen, but the range of colour change of some fishes is most remarkable.

There are two types of colour change effected by different mechanisms: *semi-permanent* and *temporary*.

Although colour corpuscles have some power of movement within the tissues, most semi-permanent colour changes are the result of alterations in the *number* of corpuscles.

If a guppy (*Lebistes reticulatus*) is kept on a black background for a month or so, the number of its melanin corpuscles increases, both below the surface layer of the skin and in the lining of the cavity of the abdomen. Flounders kept for a long time on a white background have 30% less melanin corpuscles than those kept on a black one. The dorsal fins of young trout reared in black containers have twice as many melanin corpuscles as those reared in white ones. During a couple of months on a white background, a killifish loses 90% of its melanin.

In general, the number of melanin corpuscles varies with the amount of light reflected from the background (the corpuscle concentration varies inversely as the logarithm of the reflected intensity). Thus a fish placed in a very bright light may assume a very dark colour if it is on a dark background. A fish on a light background will pale even though the light be dim.

The loss of melanin during a fish's sojourn on a white background is due in some cases (e.g. the catfish) to a degeneration of the corpuscles, and in others (e.g. the guppy) to their extrusion through the skin.

In the main, semi-permanent colour changes are the results of stimuli received through the eyes, but the chain of events bringing them about is not clear. The effect on colour change of removing the eyes varies with different species. Blind catfish develop more pigment than ever, but most bony fishes gradually lose melanin, to assume a shade intermediate to those adopted on white and black backgrounds. Minus its pituitary gland—a knob of special tissue attached to the underside of the brain and secreting certain hormones into the blood stream—a blind or eyed fish loses melanin.

Certain long-term colour changes are purely dependent upon hormones. The silvering of the trout and salmon can be produced prematurely by injecting thyroid extract. After two months' treatment, brown trout look just like sea-trout. A testicular hormone causes the redness of the breeding male minnow.

The silvering of the eel prior to its seaward descent is not a 'breeding-dress' as previously supposed. There is no

difference in the state of the reproductive glands of silver and yellow eels of the same size.

Temporary Colour Changes

Fishes react in two ways to changes in environmental colour. First they respond to the light intensity and then to the colour proper. The shade reaction is the effect of melanin corpuscle activity. The colour reaction is due to activity of the chromo-corpuscles. They are quite independent processes. In the minnow, for example, the shade change takes only a few seconds, whilst the colour change needs several hours for full development. Lampreys and cartilaginous fishes like the dogfish and skate respond to changes of light intensity only.

Different fishes vary greatly in the speed and degree of their shade adaptation. Thus the spotted goby adapts itself to altered shade in less than a minute, whereas the little goby needs several hours. The angel fish needs several minutes, the eel about half an hour, and the catfish at least 15 hours. In the killifish paling takes longer than darkening: in the eel the reverse holds.

Surface fish, like the tunny, and deep-sea species (both living in a fairly constant environment) have very little power of colour change.

Some temperate forms like the flat-fishes have remarkable powers of copying a background, even when this is as artificial as a black-and-white chequer-board (Fig. 5) but they never exhibit the versatility of some tropical fishes. The Nassau grouper can effect the most drastic colour changes, going from a deeply banded to a uniformly cream colouration in a matter of seconds.

Temporary colour changes are due to movements of the pigment granules within the colour corpuscles and to interference effects between guanin crystals. The stimulus is again received through the eyes: blinded fish cannot as a rule become adapted in any way to the background. The stimulus passes via the optic nerves to the brain and thence is transmitted to each colour corpuscle. The exact parts of the brain concerned are unknown but experiments on electrical stimulation of the nervous system of the minnows have given some indications. Stimulation of the hind-brain and front part of the spinal cord causes the fish to pale, whilst stimulation of the fore-brain makes the skin darken. Stimulating the mid-brain has no effect. All that can be said for certain is that under one kind of nervous stimulation the corpuscle granules spread out and darken the corpuscle, whilst under an alternative stimulation they aggregate as a small knot in the middle and lighten its colour.

If the two eyes receive different stimuli from the background, the colour adopted by the fish is a compromise. Thus a fish placed directly over the dividing line between a black and a white background takes on a grey shade. The melanin corpuscles appear to react to the relative illumination of the upper and lower halves of the retina, the former receiving direct light and the latter the light reflected from the bottom. From experiments in which the eyes of fishes had the upper or lower half blacked out with collodion goggles, it was deduced that if more light enters the upper half than the lower, the melanin granules aggregate; if more enters the lower half, they disperse. The two eyes of a killifish were surgically rotated, reversing the positions of the upper and lower halves, and it was found that a fish that normally responded to a light background would then give the response only when the light was presented from above. The relative lighting of the upper and lower halves of the retina does not affect the behaviour of chromo-corpuscles.

A few species of fishes have special mechanisms which allow colour changes to be made without the light having to pass through the eyes. The minnow, for example, has light-sensitive organs on the outside of the brain. The lamprey has them in the skin of the tail.

There are two main channels whereby background stimuli for temporary colour changes reach the colour corpuscles from the brain. These are the nervous system and the blood.

The two nerves supplying each colour corpuscle do not enter it, but their very fine end branches lie in close proximity to it. When these branches are stimulated by brain impulses, they secrete small amounts of hormone-like chemicals such as adrenalin and acetylcholine. The hormones produced by the ends of one nerve diffuse into the corpuscle and cause its granules to disperse; those liberated from the other nerve bring about aggregation. This nervous control is purely unconscious. Thus, in the Atlantic blackfish (*Cottus scorpius*), adaptive colour changes continue during sleep. The nocturnal paling and diurnal darkening of the lamprey are part of the established rhythm of its life, so that even then if it is kept in total darkness for a long period the changes continue.

The nervous control as a whole must be very involved in a fish like the plaice, where, as a result of two retinal images, the thousands of corpuscles react in different degrees to produce a matching mosaic. It is also strange that a fish can adapt itself to changes of environmental

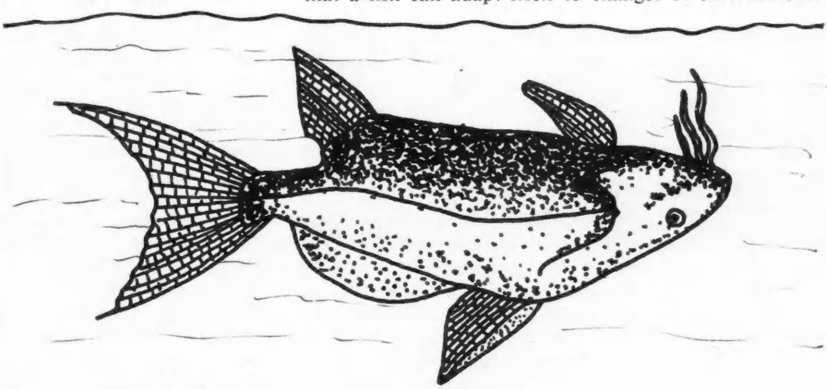


FIG. 4.—The Nile Catfish (*Synodontis*).

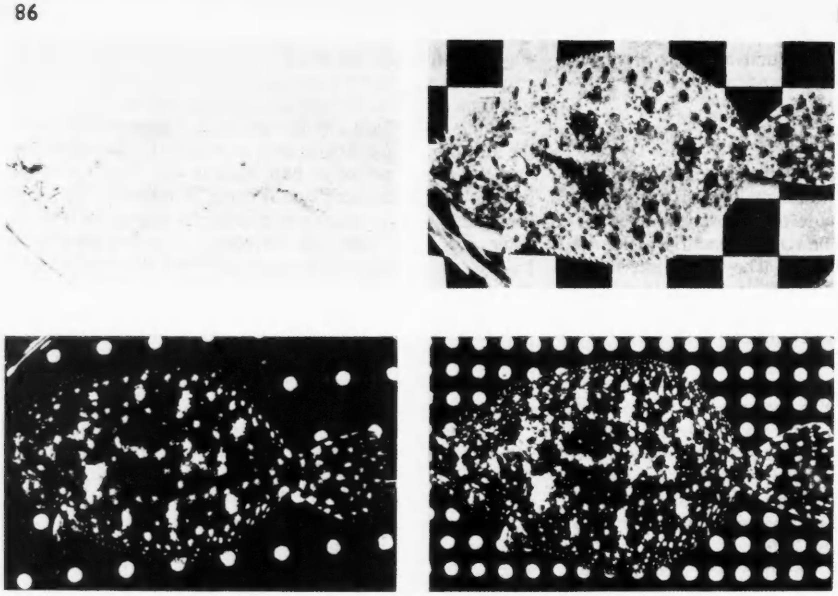


FIG. 5.—Change of pattern in flounders. These photos are all of the same individual fish in an aquarium tank under the bottom of which cards bearing different patterns were placed. (From Mast, *Bulletin of U.S. Bureau of Fisheries*, 1941.)

shade which, judging by results of training experiments, it cannot consciously appreciate.

In the eel, lamprey and smooth dogfish, migration of the pigment granules is mainly the effect of hormones produced in special glands and carried to the corpuscles via the bloodstream. The adrenal and pituitary are the chief glands concerned.

A smooth dogfish with its pituitary removed will not darken on a black background, but will do so if injected with pituitary extract. Aggregation of the granules causing paling is partly controlled by nerves. In species where colour control is purely nervous, hormone injections usually cause rapid colour changes. The melanin corpuscles aggregate in a killifish injected with adrenalin. The red colour-corpuscles of a sea-robin (*Prionotus strigatus*) also pale under this treatment.

Other factors affect the behaviour of colour corpuscles. Water at 100° F. makes a killifish pale rapidly; water just above freezing-point causes darkening within 10 minutes. Immersing a sailfin killifish (*Mollienesia latipinna*) in a 5% solution of ether or a 0·5% solution of chloroform makes its melanin corpuscles disperse, but this does not happen if the fish has been first injected with adrenalin.

Survival Value of Camouflage

The survival value of camouflage in nature has been fully demonstrated in the laboratory. In a series of experiments, 288 specimens of the mosquito fish (*Gambusia patruelis*) were kept for seven weeks in a black tank and became very dark. The same number of fish kept in a white tank for seven weeks became pale grey.

Tame penguins were allowed to capture and eat this fish at will in a grey tank. Of 270 fish eaten, 61% were dark and 39% pale grey. In similar trials in which the birds were allowed to capture the fish in a black tank, the figures were 73% pale grey fish and 27% black. The experiments were repeated using a night heron and a sunfish as predators; the results were similar.

In controlled experiments, several species of fishes adapted to light and dark backgrounds respectively preferred to lie over the background to which they were adapted when offered a choice of the two. For instance, after six weeks on a blue background, flounders were placed in a tank, the bottom of which was painted half blue and half green; the fishes swam 88% of the time on the blue side. Flounders after six weeks on a green background swam 70% of the time on the green side.

Many colour changes in fishes have the reverse effect to affording camouflage; they can probably be compared with blushing in man. The bullhead, perch and minnow turn pale when excited; plaice and flounders darken; a light-adapted turbot suddenly develops dark spots when disturbed; the Nassau grouper becomes vividly banded. Some of these change may have a frightening effect on a possible attacker and it is more than coincidental that poisonous species like the weevers, trunkfish and puffers are highly coloured. Observations have shown that fish can associate bright colours with unpleasantness. When offered white side first to fishes in experiments, certain molluscs were closely investigated; but they were completely ignored when shown coloured side up.

Emotional changes are probably effected by hormones rapidly shed into the blood.

Regular colour changes are shown by many fish species at the approach of the breeding season. The male is usually the more brilliant partner. Minnows, sea-trout, sticklebacks, and some wrasse are good examples. The red-bellied dace (*Chrosomus erythrogaster*) has a bright breeding-dress it can assume or dispel at will. Nuptial pigment may be by-products of the developing reproductive organs. They are accidentally useful in some instances, but usually lack survival significance. The females of certain tropical cichlids prefer the most gaudy males, however, so there may be some 'sexual selection' effect of colour there.

Many fishes go through a series of colour changes as part of their natural development. The salmon is a good example. The smolt, which differs so greatly in appearance from the salmon parr, has not undergone any fundamental colour changes. The barred parr marks are simply masked by the rapid deposition in the skin of a superficial layer of guanin.

Many fish, like the yellowtail snapper (*Lutianus argentiventris*), lose their pigment with advancing age. A few such as the blacksea bass (*Stereolepis gigas*) become darker.

Continued from p. 61 of previous issue]

Rubber: Its Compounding and Testing

JOHN HUNTER, B.A., B.Sc.

THE rubber technologist is interested in one property of his material which he does his best to destroy completely before he sends out his products; this is, of course, the plasticity or ability to flow of unvulcanised rubber.

Plasticities of small samples of compounded rubber can compared by three main types of instrument. The most widely used is *the parallel-plate plastometer* which measures the rate and extent of 'squashing' of a cylindrical sample under load between two parallel plates, one fixed, one movable; it is usually carried out in an oven, thermostatically maintained at 70-90° C, and the instrument is illustrated in Fig. 4. This test has a disadvantage in that it measures plasticity at low and non-uniform shear rates whereas rubber processing involves high shear rates. In spite of this, with natural rubber mixes it forecasts processing behaviour quite well, though it has not been so successful with GR-S synthetic. *The shearing-disc type plastometer* has proved rather more sensitive for use with GR-S mixes, but even this instrument, which operates at fairly high shear rates, does not always forecast accurately relative processing behaviour. The principle of the instrument is that it assesses plasticity by measuring the force needed to rotate a metal disc at a given speed in a matrix of the rubber under test at a given temperature.

The third type of instrument for measuring plasticity is *the extrusion plastometer* which can be arranged to measure the rate at which the mix, at a given temperature, can be forced through a standard die by a constant pressure. This type of instrument has the advantage of measuring plasticity under very similar conditions to those obtaining during factory extrusion. In general, however, it can be said that there is no wholly satisfactory method of testing plasticity of the raw mix. Application of the science of rheology to rubber technology is throwing light on the actual physical processes involved during deformation and there is no doubt that such thorough analysis will lead to better ways of assessing this portmanteau property at present called plasticity.

When rubber is vulcanised it loses plasticity but develops elasticity and tensile strength. The attainment of the optimum state of vulcanisation, with its time-temperature variables, is usually recognised by measuring the development of tensile strength or elasticity under various vulcanising conditions and selecting the optimum from the graph of the physical property plotted against time of cure. Fig. 1 showed the kind of curves that are obtained with various types of mix. A cruder test for rate of vulcanisation is to measure the time of retention of plasticity at a given temperature; this test is useful for determining how long a mix can stand high processing temperatures without showing premature vulcanisation or "scorching".

Several types of machine have been used to measure tensile stress-strain properties of vulcanised rubber. They all depend on stretching a suitable sample at a given rate and recording the load at various percentage elongations and the elongation and load at the breaking-point. Modern machines take ring or "dumb-bell" shaped samples of accurately known cross-sectional area and actually draw the stress-strain curve during elongation up to the breaking-point; Fig. 5 illustrates a *tensile testing machine* of the latest type. This test, as well as indicating the strength and stretchiness of the sample, also gives a measure of its stiffness by measuring modulus or the force required to produce a given percentage elongation.

Elasticity or rebound resilience is usually measured by the obvious method of dropping a weight from a known height on to the surface of the rubber test piece and recording the height to which it rebounds. The dropping weight is often in the form of a rigid pendulum with a suitably placed, ball-shaped indentor and the test is arranged so that it can be carried out at one or more temperatures above room temperature. This test gives a first approximation of the relative heat-generating properties of vulcanised rubber mixes when, in actual service, they are put through stress cycles: this is a most important subject and needs some amplification.

Motor tyres on the average small vehicle end their service lives by wearing down the treads until the fabric casing is exposed, but with the larger sizes which are used on lorries or buses a fatigue or overheating type of failure becomes more common as tyre loadings (and overloadings) increase. This is particularly the case with tyres made from the synthetic rubber now in use, which has lower resilience and consequently builds up heat more rapidly than natural rubber; a greater proportion of input energy is lost through

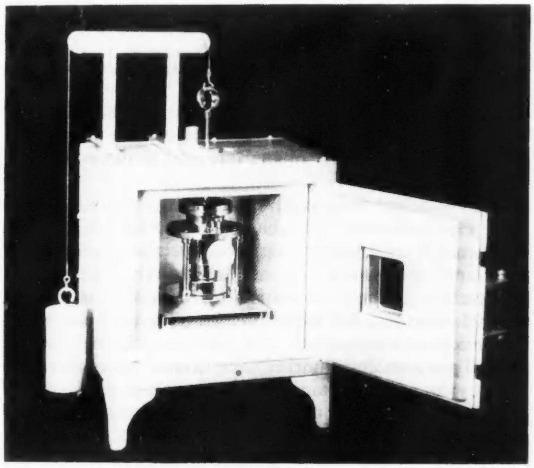


FIG. 4.—The photograph shows a parallel-plate type plastometer mounted in a thermostatically controlled oven. The small cylindrical rubber sample is compressed between the base plate and the movable centre weight which is of known magnitude. The degree and rate of compression is followed by reading the micrometer gauge at given time intervals. (*Courtesy of H. W. Wallace & Co. Ltd., Croydon.*)

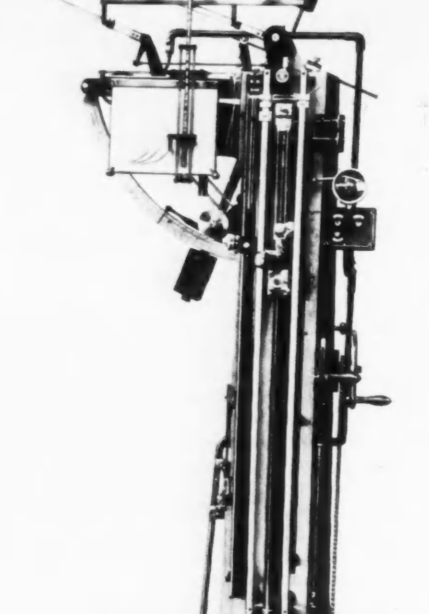


FIG. 5.—Machine for testing tensile strength. The autographic mechanism on the left-hand side draws the stress-strain curve for each sample tested. (*Courtesy of Goodbrand & Co, Ltd., Salford*).

heat generation inside the tyre. Excessive heat build-up leads to failure through a sudden deterioration in physical properties of some part of the tyre and in extreme cases this leads to a 'blow-out'.

Many different fatigue or heat build-up tests are available, most of which are based on putting a suitable vulcanised sample through repeated cycles of compressive stress and measuring either rate and extent of increase of temperature or the time taken for the sample to fail by internal collapse. *The Goodrich Flexometer*, a well-known and widely used type of machine for measuring heat build-up, will put a small cylindrical sample through compressive stress cycles of known amplitude and enables the temperature rise of the sample to be measured after various times of flexing.

The prime object of laboratory flexing or heat build-up tests must be to reproduce the approximate equivalent of service conditions, and the success or failure of the test method is judged solely by the practical value of the results as a guide to production compounding. It is not enough that the theory of the machine has been ingeniously worked out, or that the test will give results which can be accurately reproduced. Efforts to achieve this desired end have led to something approaching a long-term controversy over the right laboratory test conditions; it is possible to compare samples of different compounds by putting them through stress cycles of constant maximum deformation or of constant maximum impressed load or of some compromise between these two. Under constant deformation a soft sample will clearly have less work done on it per cycle than a harder compound, while under constant maximum load the harder sample, because it will undergo smaller deformations, will come off more lightly from the point of view of work input. Which conditions should be used in laboratory tests? This is not an academic question, since these different ways of testing can sometimes put a series of vulcanised rubber compounds in differing orders of superiority. It is clearly necessary to choose the conditions in relation to the kind of service for which the compound is being designed. In the case of solid tyre compounds there is no question, service conditions are constant maximum load stress cycles and laboratory test conditions must be similar. But the tread or casing of a pneumatic tyre in service goes through stress cycles which are neither purely 'fixed maximum deformation', depending on tyre design, load and inflation pressure, nor 'fixed maximum load' where cycles depend on load and on the stiffness of the rubber compounds involved. In other words, the deformation produced by a given weight of car on tyres of given design and inflation pressure will to some extent, not readily ascertainable, depend on the compression characteristics of the rubber in that tyre. Such considerations have often been ignored in designing heat build-up tests, but a study of recent published work shows that rubber technologists are tending to adopt compromise conditions between constant load and constant deformation cycles. This problem is described in some detail to illustrate the kind of questions rubber physicists and engineers have to answer; there are a host of other questions of a similar nature.

Accelerated Ageing Tests

Few small boys have failed to observe the falling-off in range of their catapults as the rubber ages or perishes. This is an extreme stage in a process which starts imperceptibly as soon as the vulcanised rubber article is taken out of the mould and which proceeds with varying speed, depending on the ingredients of the mix and the temperature and atmospheric conditions of service. The rate of degradation has been tremendously reduced by the use of anti-oxidants and rubber can now be used under conditions which were unthinkable twenty years ago. It is obvious that a fairly rapid laboratory test is required which will compress into a few days a service life of perhaps years, so that compounds with good ageing quality can be developed and tested. There are several recognised *accelerated ageing tests* all of which depend on employing relatively high temperatures, some in the presence of air under atmospheric pressure and others under a high pressure of oxygen. For natural rubber mixes the conditions are usually at 70° C. under 300 atmospheres pressure of oxygen, or at 80° C. in freely circulating air. Hotter-running GR-S synthetic is usually tested at 100° C. in air, but even higher temperatures have been used. The severity of the test is controlled by varying the time of exposure to test conditions and the chosen physical properties are compared before and after ageing. Again, satisfactory

correlation with service behaviour has been achieved, but not perfect correlation.

Some of the most important types of physical test in common use have been considered. There are, however, many others, some of general and some of specialised interest. Hardness and permanent set (the non-elastic part of deformation) are important in many types of rubber product; tyre treads must have good resistance to abrasion and flexing; tubes must have high resistance to tearing; special hose must show resistance to swelling on immersion in certain solvents; rubber parts for aircraft must have low freeze or brittle-points; some rubber mixes must be good electrical insulators while others must show appreciable conductivity. There are a host of specialised properties that the rubber compounder may be called upon to produce and he must have available all the necessary laboratory apparatus to measure and compare these properties.

About the technique for carrying out some of these tests there is a considerable measure of agreement, so that different laboratories can readily interpret the results of each other's work. Much useful pioneering in this direction has been done by the British Standards Institution and the American Society for Testing Materials. However, tests for abrasion resistance, crack growth, behaviour in solvents, resistance to low temperatures and heat build-up are still in a rather chaotic state and badly need standardisation.

The first need of the rubber technologist is for better information about the way rubber does its job. Investigation is required into the flow characteristics of unvulcanised rubber and the mechanism of such processes as abrasive wear, tearing and cracking, as well as the exact type and frequency of stress cycles undergone by rubber in various kinds of service. It is essential to understand the nature of processes in order to develop tests for materials undergoing them, and the results of such fundamental analytical work should enable the more rapid development of standard tests for various properties for each of which there are, at present, a variety of tests, each with its partisans. There is room, too, for an International Conference on Rubber and Plastics test methods, which might do much to improve present conditions as well as affording a welcome opportunity of establishing much-needed international contact between at least one section of the world's technical and scientific workers.

Secondly there is scope for a far wider adoption of the methods of statistical design and planning of experiments and analysis of results. It is impossible to discuss this subject in detail here, but there is no doubt that the correct use of such techniques cannot but improve the efficiency and consequently minimise the cost of testing. They would enable the technologist to know just which differences in properties revealed by his tests are likely to be significant and which are likely to be due merely to experimental error and, furthermore, would lead to a better knowledge of the causes of that error, which in turn would lead to improvements in the design of the apparatus and in the accuracy and sensitivity of the tests.

Lastly, similar statistical methods could, with great benefit, be widely applied to the correlation of laboratory test results with service results. The ultimate value of a test lies in its ability to forecast service behaviour; the judgment of how good the correlation is has been for too long a matter for personal whim and opinion. Opinion has, no doubt, often been right, but it has sometimes made quite bad mistakes. Modern statistical technique, as described in such books as *The Design of Experiments* by Professor R. A. Fisher and *Statistical Methods* by G. W. Snedecor, will give a measure of the correlation as well as of the error involved and, under these circumstances, the value of any test result as a guide to executive action can be assessed in terms of mathematical probabilities rather than pious hopes. When this technique is generally used rubber technology will have taken a great step towards the science which it is industrially and economically necessary that it should become.

PROGRESS OF SCIENCE—*Continued from p. 71*

of these functions fairly well but their prophylactic value is limited as they are active only against the blood stage of the parasite. One very important property of paludrine is its power of attacking the parasite from the instant it enters the body. (In the article 'Fighting the Malaria Germ', DISCOVERY, March 1945, p. 78, there is a diagram of the mode of action of quinine, mepacrine and pamaquin; paludrine attacks the three stages, A, B and C.).

It is perhaps not generally realised that among the three hundred million estimated to suffer from malaria every year the great majority, particularly among the natives of Africa and Asia, cannot afford quinine or mepacrine for prophylactic purposes or even for treating active attacks. Although no details are available concerning the cost of paludrine, it is evident from its chemical constitution that it will prove relatively cheap. Furthermore, it can be taken by mouth, another essential quality of a drug to be used on the large scale for prophylaxis.

As it was hoped to discover a drug with a much wider range of action than any previously known the search for a new antimalarial was made among entirely new classes of chemical substances. Activity was found first in a derivative of pyrimidine. Further patient research showed that it was possible both to simplify this original molecule and at the same time to enhance its antimalarial activity. Eventually a combination of high antimalarial activity and low toxicity towards the tissues of the body was found in *paludrine*, which chemically is 1-*p*-chlorophenyl-5-*iso*propyl-biguanide.

Paludrine has had extensive clinical trial both among returned service personnel in this country and in malarial districts abroad. The results have been most satisfactory, both for treating active fever and as a prophylactic, in cases of benign tertian malaria (caused by *Plasmodium vivax*) and malignant tertian malaria (caused by *Plasmodium falciparum.*) The power of paludrine to prevent subsequent relapse is still to be assessed but, although evidently not perfect, it compares favourably in this respect with both quinine and mepacrine.

Science and Human Welfare

MANY countries and many scientific bodies were represented at the "Science and the Welfare of Mankind" conference that was held in London on February 15-17. Scientists had come from Holland, France, Poland, the United States, Canada, China, India and S. Africa to attend it. The conference, which was sponsored in the first place by the Association of Scientific Workers, was supported by the British Association of Chemists, the Institution of Professional Civil Servants (the body to which Civil Service scientists belong), the Association of University Teachers, the Physical Society, the Nutrition Society, and the Institution of Electronics.

That such a conference should be held was first advocated publicly in a statement issued by the A.Sc.W. which dealt with the international and social implications of the release of atomic energy, and naturally these matters figured prominently in the speeches. There was remarkable unanimity on the necessity for international control of atomic energy, inspection measures and so on. In this connexion Professor P. M. S. Blackett made a very provocative contribution—it appeared to surprise the session's chairman Sir Robert Watson-Watt, and probably surprised many in the audience—in which military realism rather than scientific idealism was the keynote.

'Official secrets' received plenty of attention. This theme was given heightened topicality, for while the first session was in progress the ticker tapes of Fleet Street were pouring out a few facts and a great deal more speculation about the 'spy hunt' in Canada. The sound of the 'official secrets' whip that had been cracked by the Canadian Prime Minister echoed in the conference hall. The scientists, however, did not need to re-write their speeches to meet the incident. And without having to write in new references to official secrecy they were in close agreement on this issue. So much so that the *Daily Express*, requiring to justify its headlines *ATOM SPIES: AMERICANS DEMAND FULL PROBE: LONDON SAYS CHECK UP ON ALL SCIENTISTS* had no difficulty in finding apt quotations—out of context, of course—from the speeches of five of the speakers. It was left to an M.P., Mr. L. J. Solley, to relate the 'witch hunt' to the threats of prosecution that Mr. Churchill and Mr. Bevin made in the House of Commons last November.

The Impending Famine

The imminent famine is more immediately ominous than the atomic bomb. Several speakers analysed the cause of the world-wide famine, but all came to the conclusion that nothing could be done to avert this disaster apart from mobilising scientific opinion behind measures to secure the most equitable food distribution.

In summing up the conference Sir Robert Watson-Watt regretted that they had offered no "immediate régime for the patient". The general prescription that was offered resolved itself into a number of long-term proposals. The gap between the natural sciences and the social sciences must be narrowed; so must the gap between science and the humanities. The scientific method must be brought into general education.

The 'ivory tower' scientist was entirely absent from the platform of this meeting. In one field—nuclear physics—it was pointed out that the ivory-tower refuge had in fact been blasted into oblivion by the atomic bomb. In other fields all speakers recognised that scientists have to accept their full democratic responsibilities.

The chair at the first session—devoted to the theme "Science and world needs"—was taken by the President of the Royal Society, Sir Robert Robinson. In his opening remarks he underlined the extent to which co-operation is essential in scientific work—"in scientific affairs we are all socialists," he remarked. Organisation did not mean control; co-ordination was consistent with independent thought and action. He referred to the need for putting the scientific house in order, but expressed himself against the suggestion for a Ministry of Science; he thought the need was for science to permeate all ministries.

A Government Speaker

The Government was represented at this session by Mr. Herbert Morrison, Lord President of the Council, under which office comes the Department of Scientific and Industrial Research, the Agricultural Research Council and the Medical Research Council.

"We are in a time when the sciences, and especially the physical sciences, have developed so rapidly that even the scientists themselves have to come out of their remoteness and are attempting, somewhat belatedly perhaps, to visualise the social significance of their work," said Mr. Morrison. "This will probably lead to a crossing of frontiers between the various sciences, and there can be no doubt that their co-ordinated approach to world problems will enormously increase our powers. If economic and social sciences had developed today to the same stage as the natural sciences we should be living in a very different world."

Mr. Morrison held that much of the hard work of scientists had been wasted because they have been content to lose interest in its final development and distribution. Of Government plans for science, he said that they were determined to organise so that no crumb of scientific knowledge that may benefit the community shall be wasted. "We must keep science free and unchained, but we need over the whole field of science a combination of freedom, initiative and social service. He would be a foolish man who tried to set a limit to our material, intellectual or spiritual development."

TUC and Science

Mr. G. W. Thomson, a council member of the Trades Union Congress, said that the Labour Movement set up a science advisory committee as long as 30 years ago. He referred to the resuscitation of the Scientific Committee of the TUC, on which will serve three TUC council members and six representatives of the Association of Scientific Workers.

A Chinese agricultural scientist, Dr. Tu Chang Wang, pointed out the moral of the pre-war paradox of starvation in the midst of plenty—social scientists must be enlisted to put matters right at the distribution end. Scientists should be well represented in the various levels of United Nations Organisation. In China industrialisation and the application of science in agriculture must go hand in hand. His country was very short of scientists, and aid was needed from outside. Here Dr. Chang Wang paid tribute to the work of Dr. Needham's mission. The world would perish or advance as a whole, and an international scientific problem needed a very strong international scientific body to solve it. Science should be strongly represented throughout the United Nations Organisation.

S. Africa Needs Scientists

The next speaker, Miss P. M. Cooke, from S. Africa, had prepared her speech at a few hours' notice, but it provided further proof that public speaking is now second nature to a large proportion of younger scientists, and such spontaneity coupled with breadth of vision augurs well for scientific conferences held in the immediate future. Miss Cooke said S. Africa needed more scientists of all kinds—and for industrial, building and medical research in particular. A Council of Scientific and Industrial Research had been set up under Brigadier Schonland. Erosion and nutrition—50 % of S. Africa's population are undernourished—call for immediate investigation. Advance would not be possible without a vastly expanded educational system; at present the natives were hardly reached.

Professor J. M. Burgers said that research continued in Holland during the occupation, and some reorganisation of research arrangements was carried out during those war years. In a small country like Holland, close co-operation between universities and industry was essential: completely separate equipment for the two kinds of research was impossible. He called for freedom of scientific intercourse—freedom to travel (leading to removal of passport restrictions), removal of secrecy, and easier telephonic communication. (The latter, suggested the chairman, would soon cut the knot of secrecy.) Perhaps symposia could be arranged by radio.

Dr. M. Mathieu, of Lille University, said the French Association of Scientific Workers, of which he is secretary, was formed by scientists of the Resistance

Movement immediately after the Liberation of Paris. Its members numbered 1100, all being scientists engaged on pure research.

Atomic Bomb Politics

Dr. Grant Lathe, a Canadian scientist, spoke of the inevitable disaster that would result from atomic bomb politics. Canada was spending only one hundredth of what America is planning to spend on research.

Dr. John A. Simpson, an American scientist who worked on the atomic bomb project, and a representative of the Federation of Atomic Scientists, said that the publicity scheme organised in the States to inform the public of the full implications of atomic energy had reached 10-40 million people. Only a supranational body could secure control of atomic energy.

Dr. H. M. MacNeille, of the Office of Scientific Research and Development, said that the U.S. spent 300 million dollars on research before the war; two-thirds of it went in industrial research, a sixth in Government work and a sixth in non-profit-making institutions. The ratio was changed by the war; Government research was increased tenfold.

The second session—its theme was "The implications of recent scientific development"—was presided over by Dr. C. P. Snow, a former editor of DISCOVERY and now scientific adviser to the Civil Service Commission.

The first speaker, Dr. Stephen Taylor, M.P., concerned himself with trends of medical advance. He foresaw great progress being made in the near future on the biochemical side and in psychiatry. In the field of chemotherapy he singled out the efforts being made to find a drug that would attack the tubercle bacillus. He mentioned the use made by the Army of psychiatrists, for personnel selection and aptitude testing. The electro-encephalograph provided a means detecting mental abnormality, while convulsion therapy and prefrontal leucotomy (a surgical operation involving the 'inhibition centre', the prefrontal lobes of the brain) offered good prospects for improving certain abnormalities. There were not nearly enough doctors; 10,000 were needed to ensure that everyone could have a complete medical examination once a year. The public must be educated to regard the doctor as a scientist and not as a magician. Dr. Taylor also spoke of the need to make specialist services available to all patients.

Challenge to Agricultural Science

Dr. H. L. Richardson, agricultural adviser to I.C.I. on problems of overseas agriculture, said that until medicine brought birth control to the backward countries agriculture must be made more scientific if it was to feed the increasing population of countries like India. Peasant agriculture was generally very inefficient; the average yield of wheat in Russia and India today is scarcely higher than the 8-10 bushels to the acre obtained in Britain in the Middle Ages. The British figure is now 35 bushels. "It is a scientific certainty that in India and China the production of food crops can be increased by at least 25% by the introduction of modern scientific methods", said Dr. Richardson. Japan has already made good use of artificial fertilisers; in 1940 three million tons were used by Japan's peasant farmers—more than the total used in Britain.

Mr. F. Le Gros Clark, the nutrition expert, emphasised one horrible aspect of the present position—he pointed out that we were able to calculate with certainty how many millions would die from famine, yet we could do nothing to stop those deaths.

Atomic Energy

Professor M. L. E. Oliphant took up Mr. Clark's point, and suggested that it might become possible to augment the dwindling reserves of phosphorus with supplies of this element made by transmuting aluminium. How to use atomic bombs was now out of the hands of scientists; it was the concern of the politicians and the military men. "That explosion in July in the American desert shattered one of the most fruitful fields of scientific endeavour—nuclear physics. That is a pity in some ways. It was a great field for pure and distinerested research." Professor Oliphant described in broad outline how the bombs were made and what happens when a bomb explodes. Of the atomic pile, he said it was easy to control the output, but there were metallurgical and technological difficulties to solve which would have to be tackled in a big way. Britain had greater need of atomic energy than the U.S. with its vast supplies of coal, oil and water power. The same was true of Australia, China and India. "Our present policy won't get us atomic energy within twenty years, but a sensible policy might get it—in an experimental form—in five to ten years," he commented.

Sir Alfred Egerton spoke of the importance of chemical engineering, illustrating his remarks by reference to the remarkable wartime achievements in the production of synthetic rubber, RDX, penicillin and plutonium. 500,000 tons of synthetic rubber were made in America within two years of starting on the project. He conveyed the scale of penicillin production in the States by mentioning that each American plant with a capacity of 100 million units of penicillin a month handled a million gallons of metabolite liquor each month.

"The responsibilities of scientists in modern society" were discussed at the third session. Professor A. V. Hill presided. The other sciences, he said, lagged many centuries behind medicine in the ethical approach of their practitioners to their job. Professor Hill quoted from the Hippocratic Oath, which incorporated an ethical injunction and the scientific claim to decide by observation and experience. He went on, "If standards of truthfulness, frankness and integrity are relaxed either for political motives or for private ambition and gain; if fraud, dishonesty and self-deception are not denounced, if mistakes are not honestly acknowledged and corrected, if propaganda is accepted in place of fact; if the common prestige and goodwill of science are prostituted for base, sectional or selfish purposes; if secrecy or secretiveness is accepted as a normal condition of scientific work; if age, prestige or authority, if race or nationality, is allowed to hinder freedom of intercourse between scientists of honesty and goodwill; if there is widespread failure to recognise an unbreakable obligation that the benefits of scientific discovery must be regarded as a sacred trust for all mankind; then science itself may become impossible as a calling for free, honest and decent men, while its exploitation for sectional gain or national aggrandisement may lead to conflict and destruction instead of co-operation and welfare." He recommended patiently building from present foundations; the body scientific could only grow gradually, as does a living organism. There was needed the inspiration of a great ideal, a common interest and standard of ethical behaviour, a common refusal to sacrifice or exploit a universal good for a temporary or sectional advantage.

A Dangerous Fallacy

Professor B. Farrington said many would like to call a halt to invention and discovery so as to give man's moral development time to catch up with his science. That idea was based on a dangerous fallacy. Science was not antipathetic to morality, and indeed no morality was possible unless based on test and knowledge. In the building of human conscience, science was the main agent. There were, as Bacon pointed out, 'climates of opinion' in which science could not flourish, but scientists needed to be better educated historically to understand that. He criticised the character of academic history, citing Fisher's *History of Europe* with its failure to analyse accurately the Russian Revolution and Fascism as proof of the 'bankruptcy of contemporary historians. Political history could not be isolated from economic history, in which invention played a part of great importance. To make the average citizen conscious of the history of humanity during the last 6000 years would be a better guide to conscience than had yet been provided.

Professor J. D. Bernal said that in the Renaissance science and industry was unplanned for the reason that people were breaking away from the traditional way of doing things. Now we were afraid of the results of the unplanned efforts of the Renaissance and the Industrial Revolution. Planning without democracy was not effective planning; there must be no blind devotion to duty as in the Nazi State, which was much less efficient during the war than was Britain. "The planning of the modern state and the modern world must be integratedly democratic from the bottom to top," he remarked. Referring to atomic bomb secrecy, Professor Bernal said that the slowness of sharing atomic energy information was the major cause for the continued and dangerously increasing tension in the world. "We would not have anything like we are having in Canada if we had full exchange of scientific information."

Mr. Arthur Horner spoke bluntly of the scientists' responsibilities. The workers were still suspicious, but their interest had been aroused in scientific matters by the magnificent contribution of scientists to the defeat of Fascism. The scientists could, however, expect full support from trade union leaders in securing the fullest use of science. "You must appeal to the broad mass of the people, explaining the nature, workings and use that can be made of it. You must inform them of all vested interests seeking to restrict and hold back the application of your discoveries."

The final session began with a contribution from Dr. Julian Huxley who spoke of the things that UNESCO (United Nations' Educational, Scientific and Cultural Organisation) might do His speech is to be found on pp. 72-3 of this issue.

Dr. Dorothy Needham and Dr. D. P. Riley briefly described the work of scientific liaison that they had performed as 'field workers' in China and France respectively. They were followed by Professor A. Proca (France), Mr. V. Stott (of the Institution of Professional Civil Servants), and Dr. Ossowski (Poland).

Atomic Bombs and UNO

The Association of Scientific Worker's president, Professor P. M. S. Blackett, devoted his time to a consideration of the Atomic Energy Commission. He put the power of the first atomic bombs into perspective by pointing out that they killed scarcely more people than were killed in a single heavy attack on German cities. He did this in order to emphasise his point that all weapons of mass destruction must be outlawed internationally.

Professor Blackett then dealt in some detail with the procedure of the Security Council of UNO and held that the 'veto' clause was vital to international control of atomic energy. Sanctions could not be brought against a Great Power, and he saw the only hope as lying in agreement of the Great Powers not to fight. The voting rules of the Security Council must only allow the voting of sanctions where there was requisite force to carry them out; otherwise international law would not be enforceable, and the law would be brought into disrepute. Atomic war would be most disastrous to a country like Britain, said Professor Blackett. Atomic weapons, he considered, could play no part in the armoury of the United Nations, and similar arguments applied to other weapons of mass destruction—biological and large-scale bombing for instance—for they were unsuitable in any 'police' type of war. If a small country had to be restrained from attacking a neighbour it might seem to be cheaper to wipe out its capital; but in the long run when the rebuilding of the destruction is taken into account—not to mention humanitarian considerations—weapons of mass destruction were not so 'cheap' as they appeared. Atomic bomb stocks could not be handed over to UNO. Of all the Great Powers, Britain could least afford to see an atomic arms race develop. The complete elimination of atomic weapons, as proposed in the Assembly of the United Nations, was the only solution. The public opinion of Britain and other countries must support their Governments in pressing this view.

Dr. John A. Simpson followed with a detailed examination of the inspection measures necessary to ensure that atomic bombs were not made in secret. His conclusion was encouraging; 'atomic' activities would be hard to hide, while there would always be some scientists prepared to rise above patriotism and report infringement of international agreements on atomic power to the international commission. There must be complete freedom of publication, and he recommended the setting up of an international atomic laboratory (which he thought might make inspection obsolete; here readers may recollect that DISCOVERY suggested in December last that an international atomic institute, if it showed a clear lead over what had been achieved in secret by any single nation, would operate as a strong deterrent to a breach of the peace).

Dangers of Secrecy

Professor Frédéric Joliot, France's Commissioner for the Development of Nuclear Energy, had sent a communication to the meeting which was read by a compatriot. He called attention to the fact that French workers were the first to effect the liberation of nuclear energy; after the fall of France French scientists like Halban, Kowarski, Gueron and Goldschmidt escaped and put their knowledge at the disposal of the Allies. He considered the position taken up by the U.S. as very dangerous; the retention of bomb secrets appeared as a means of exerting pressure in bargaining. For a long time scientists had been accustomed to industrialists insisting on technical secrets, but this was the first time that the diffusion of the results of pure science had been forbidden. Once accepted, this principle of secrecy could be extended to all fields of science, to slow down and even halt the world's progress. Civilisation was based on communication; to stop the circulation of information would be to go back to prehistoric times.

An Indian scientist Mr. N. S. Banerjee, said that there was a great need to encourage the 'food-bearing' sciences in his country, where mathematics and physics were strong but the biology was weak.

(The Association of Scientific Workers is preparing a booklet on the conference, which will be published shortly by the Temple Fortune Press.)

Far and Near

German Scientists in Britain

THE mystery over Professor Hahn was dispelled by a Government statement in the House of Commons last month. Professor Hahn, said the Prime Minister, was brought to Britain together with other German scientists who had worked on atomic energy. They had since been returned to Germany where they would be allowed to pursue fundamental research within any scheme of research approved by the Control Council. The policy under which German scientists are being brought to Britain was further explained by Sir Stafford Cripps, who stated: "It is proposed to recruit, on the recommendation of the responsible Department, a strictly limited number of German scientists and technicians of the highest grade for service in this country. Any Germans brought in under this scheme must be politically unobjectionable and they will be subject to strict supervision while they are here. It is intended that in general these experts should work in government establishments, or for research associations sponsored by the Department of Scientific and Industrial Research, but, in approved cases, their services may be made available to individual firms. In no case will a German be brought in to undertake work that could equally well be performed by a British subject. An Interdepartmental Panel under the chairmanship of Sir Charles Darwin has been set up to examine the requirements of British industry in this matter and to scrutinise the credentials of those whose names are put forward. Our American and Russian Allies are pursuing a similar policy."

Research Studentship at Trinity

IN accordance with its usual practice, Trinity College, Cambridge, announces the offer of a Research Studentship open to graduates of other Universities who propose to come to Cambridge in October next as candidates for the degree of Ph.D. The value of the Studentship may be as much as £300 a year. Candidates must not have reached the age of twenty-six before May 1, 1946. In certain circumstances an election may be made to an additional Studentship.

The College also offers Dominion and Colonial Exhibitions to students of Dominion and Colonial Universities who wish to come to Cambridge next October as candidates for the degree of B.A., M.Litt., M.Sc., or Ph.D. These Exhibitions are of the titular value of £40, but the College Council has power to award additional payment.

Candidates should apply through the principal authority of his University, and applications should reach the Senior Tutor of Trinity College (from whom further particulars may be obtained) by May 1, 1946.

Science Museum Reopened

ABOUT a third of the Science Museum was reopened to the public on February 14. The children's gallery and the locomotive gallery are now open, and special exhibitions have been arranged on atomic energy, X-rays and their application, and the quartz crystal clock. The original Wright aeroplane is on view, and the aeronautics gallery will be reopened as soon as plate glass can be obtained to reglaze a number of damaged cases. A large part of the portion of the museum now open is occupied by a Ministry of Aircraft Production display of German aeronautical developments, including a V1 and V2, a piloted flying bomb, several aircraft types, and numerous aeroplane instruments and accessories.

Hartley and the Spectroscope

TODAY'S widespread applications of spark and arc-spectra in laboratory and industry all derive from the inspired work of Sir Walter Noel Hartley, F.R.S., born just 100 years ago. He published 50 papers on the subject.

Hartley was a Dublin professor, a founder of the Institute of Chemistry, and a Longstaff medallist of the Chemical Society. Using for his researches Dr. Miller's spectroscope, with quartz prisms and non-achromatic quartz lenses, he was the first to set the complete spectrum on a flat plate, the first to use a dry plate for this; the first to include a number of photographs on one plate for comparison. By 1884 he had photographed spark-spectra and had made a complete table of wave lengths. He was also first to show that gallium was an element of the sun and of many stars; and to prove the wide distribution not only of small amounts of lithium, but of the rare earth metals.

A first groping towards modern ideas on electronic structure came with his establishment of the relation between wave lengths of lines formed by analogous elements.

Geologists and D-Day

PROFESSOR F. W. SHOTTON, geology professor at Sheffield University, speaking to the Geological Society of London on the geological work in the invasion of Europe, claimed that no military operation in history had been planned in the same way as the invasion of France. He said that geologists worked for years on the problem of where the invasion should take place. The exact spot was decided upon more than a year before the landings actually took place.

The geological make-up of the Caen-Arromanches area, with its wide plateaux of Middle Jurassic limestone capped by loess, providing numerous flat sites covered by a soil likely to drain quickly in winter, allowed the possibility of an unusual concentration of airfields and was therefore one of three major controlling factors in the choice of the invasion area. That the area chosen was suitable was shown by the fact that before the break-out from the beachhead there were 20 airfields operating within it.

The nature of the beaches was of great importance for the landing operations. Although Intelligence had told the geologists the beaches were sandy, it was found from photographs and by comparison with British beaches that some peat and clay outcropped in places. (The much publicised Commando landings that were undertaken in order to obtain specimens of the beach material were not much use, said Professor Shotton.)

How the peat and clay on the landing beaches would affect the invasion was not known. A similar beach was found at Brancaster, Norfolk, and all sorts of vehicles were tested on this beach. It was found that wheeled vehicles stuck in the peat and clay, but tracked vehicles could get over the peat all right. Where there was a covering of 10 inches of sand all vehicles could move.

Effects of bombing were also tested. A sandy beach presented no difficulties as craters filled up with the incoming tide. But where sand overlaid clay craters did not fill up at once owing to the explosion creating a lip of clay all round the crater which prevented the movement of sand. This was a menace to vehicles, but the difficulty was overcome by bulldozing the lip of the crater away.

As a training ground for the soldiers who would have to climb 120-foot-high cliffs west of Arromanches, the geologists found suitable cliffs at Swanage for the Army to practise on.

Other important geological work was the provision of water-supply maps which could be read by non-geologists, and maps showing the position of quarries for the provision of sand and roadstone.

Beach intelligence work was done on the coasts of Walcheren and Beveland previous to that assault. And for the final attack across the Rhine, the bed and approaches of the river were investigated in detail.

Artificial Red Sandstones

IN a lecture given to the Royal Society Lord Rayleigh described experiments he had made with a view to finding out the conditions under which red sandstones are formed. Field observation in the Tyne valley confirmed a suggestion made by Sir Robert Robertson that in some cases at least red sandstone may derive its iron from chalybeate water, which is a solution of ferrous bicarbonate. Starting with this idea, it was found experimentally that red or yellow sandstone could be produced according to the circumstances under which the chalybeate water deposited its iron. If the chalybeate water is evaporated on the surface of a solid body, whether a sand grain or the surface of a glass bulb, a red coating results. The same occurs when evaporation occurs in air from an undisturbed liquid surface, a red skin forming on the liquid. If, on the other hand, the liquid is agitated with air, as in a stream in the open, a light yellow precipitate forms throughout it. This when formed settles down to a yellow deposit on sand grains, twigs or other solid surfaces, or on solid sandstone rocks.

The red and the yellow deposits both consist of hydrated ferric oxides. It is difficult to say from a chemical point of view what is the essential difference of constitution between them. The degree of hydration is not rigidly constant for different red preparations, and tends to be somewhat less for the red material than for the yellow.

The main point is that red sandstone has been produced which closely imitates the natural product. This has been done without using high temperatures and using beside the sand itself only natural chalybeate water of common occurrence in nature.

Personal Note

PROF. E. K. RIDEAL, Professor of Colloid Science in the University of Cambridge, has been appointed Fullerian Professor of Chemistry in the Royal Institution and director of the Davy Faraday Research Laboratory on the retirement of Sir Henry Dale on September 30, 1946.

A New Comet

A NEW comet was discovered on February 2 by Timmers at the Vatican Observatory. It is a faint object—about magnitude 9—but several British observers have kept it under view and have sent in the results of their observations to Dr. M. Davidson, the Director of the Comet Section, British Astronomical Association, who has computed an orbit. The comet is in the Great Bear, but is still a faint object, and will almost certainly remain so as it is receding from the earth. On February 17 it was about 100 million miles from the earth and 173 million miles from the sun, and at the middle of April it will make its closest approach to the sun—160 million miles. It is receding from the earth by about 180,000 miles a day at the time of writing (February 20), and is becoming slightly fainter.

Jannsen Medal for Astronomer Royal

A PLEASING little ceremony, almost unwitnessed, took place in the Octagon Room of the Royal Observatory recently, when the Astronomer Royal, Sir Harold Spencer Jones, was presented with the Prix Jannsen of the Société Astronomique de France for 1945. The occasion was the visit to Greenwich of five French astronomers, MM. Danjon, Lyot, Chalonge, Couder, and Fegrenbach. M. Lyot, as this session's President of the Société, presented Sir Harold Spencer Jones with the Medal. Among past recipients of the Prix Jannsen, instituted in 1897, are four British astronomers:—Anderson (1901), Cowell and Crommelin (1910), and Eddington (1928).

Scientific Film Societies Confer

REPRESENTATIVES of scientific film societies from all parts of Britain attended a meeting in London on January 19, organised by the Scientific Film Association, at which they saw new scientific and documentary films. The meeting served a useful purpose in helping to co-ordinate the activities of the various societies in relation to the S.F.A. It is hoped to hold similar meetings in the North and in Scotland in the future.

A Danish one-reeler called *The Toad*, containing excellent close-up photography of the animal's struggles against its enemies, was followed by *Institut Pasteur*. This French documentary dealt with the work of the institute in Paris. The film, a copy of which has been presented to the S.F.A. by the French Government, also showed new microscopic techniques. There followed *The Microscope*, a classroom film demonstrating correct method of use; *Proud City*, a documentary about the L.C.C.'s scheme for a replanned London; two Canadian films in colour, *Life on the Western Marshes* and *Salmon Run*, dealing respectively with the organised preservation of water fowl and with scientific control of the salmon industry centred on the Fraser River; and finally *Round Pegs*, a film about the Army's intensive selection procedure carried out with each new recruit to determine for what branch of Army life he is best fitted.

Afterwards Miss Helen de Mouilpied spoke about the work of M.O.I. and the organising by the Central Film Library of 1,300 non-theatrical shows per week. In the following discussion, Mr. Arthur Elton, speaking about the possible influence of the Scientific Film Society movement on the public cinema, pointed out that each society could in time become a local force in film matters. By stimulating a critical interest within their own districts, the societies could help to create public opinion about scientific films, and through them about science generally. The S.F.A. proposed the formation of a National Council of delegates from Scientific Film Societies.

Streptomycin Goes Into Production

THE American chemical manufacturers Merck and Co., one of the largest producers of penicillin, are to embark on commercial production of another antibiotic derived from a mould, streptomycin.

Streptomycin first attracted particular attention because of its power of inhibiting the growth of the tubercle bacillus and in this connexion was discussed in DISCOVERY (March 1945, p. 68) shortly after the publication of the first results concerning its isolation and properties. The results in tuberculosis treatment of experimental animals continue to be promising but its value in the treatment of human tuberculosis can be decided only by very extensive clinical trials; it may be several years before a definite answer can be obtained. Streptomycin also shows great promise for the treatment of many kinds of infections which do not respond satisfactorily to penicillin or any other drug.

Streptomycin is produced by a microorganism, *Streptomyces griseus*, belonging to the order known as the Actinomycetes, which are in some respects intermediate between bacteria and fungi. The specific mould was first isolated from the soil. Streptomycin can be isolated in the form of crystalline salts from fluids on which this organism has grown. Chemical evidence shows that streptomycin belongs to the class of substances known as the alkaloids and contains only the elements carbon, hydrogen, nitrogen, and oxygen. A suggested empirical formula is $C_{10}H_{19}O_7N_3$.

The main interest is, however, in its biological properties. Besides inhibiting the growth of cultures of bacteria, such as *Bacillus subtilis* and *Staphylococcus aureus*, which are sensitive to penicillin, it also has a strong inhibitory effect on a considerable range of other bacteria. Among these may be mentioned *Brucella abortus*, the cause of contagious abortion in cattle, *Pasteurella tularensis*, the cause of tularaemia, and *Pseudomonas pyocyaneus*, commonly present in infected wounds. With this antibacterial activity is combined a low toxicity. Streptomycin, like penicillin, is introduced into the blood stream by injection. Weight for weight, its antibacterial activity is a good deal lower than that of penicillin but it has the advantage of being much more stable so that problems of production and storage are very much simplified.

Army Education—Formation Colleges

FORMATION COLLEGES may be described as the highest peak of attainment in the Army Education Scheme. They are the final goal to which the Unit paths converge; they give the highest level of education which the student in the Army will ever receive (writes our Services correspondent). They will, undoubtedly, become a permanent feature of Army Education in the post-war years: Mr. Lawson, opening Eastern Command Formation College at Luton, described them as the nucleus of the future Army Educational System.

They are, in a limited sense, miniature 'universities' except that the student, instead of spending three years at one, goes for a month only, usually to study, or to take a refresher course in, one particular subject. It is a cramming course, but at the same time an attempt is made to preserve the liberal atmosphere of a university. There are social activities in the evening, free periods for private reading, an excellent library and reading room, and an intermingling of and discussion between all ranks. The colleges are residential and are usually housed in some large private mansion, set in its own grounds, which the Army has taken over.

There are, at the moment, five of these Formation Colleges in Great Britain (one in each Command), and three abroad (B.A.O.R., C.M.F., and M.E.F.). Anybody, irrespective of academic qualifications, can apply for a course at one of the colleges, the only limitation being the number which can be received at a time—a thousand is about the average number. Preference is being given to applicants who are due for early demobilisation. The number of applications for courses far exceeds the vacancies, and thousands of applications have been refused each month.

At the beginning, the colleges suffered from growing pains in the shape of inadequate equipment. An atmosphere of Dotheboys Hall hung around one particular college which, due to open on a Monday, was faced on the previous Saturday with no equipment of any sort except stationery. Intending students of electrical engineering were asked, when they arrived, if they would mind learning by practice, and wire up the dining-hall; plumbers and decorators, come to brush up their trades, found as much work to do as in a busy season at home. However, these initial setbacks are now a thing of the past, and the colleges are well organised upon a permanent basis.

The instructors at the colleges are chosen by a selection board, and are picked from the many qualified men, schoolmasters, technicians, and others who are serving in the Army of today. The standard of instruction is, consequently, extremely high, and the colleges are not faced with the same difficulties over staff as are Unit Schemes of Education.

Formation Colleges are, in a sense, an adjunct to the Unit Educational Schemes in so far as their syllabuses cover the same subjects (Arts, technical, and semi-vocational), while their courses, although they last only a month, are more intensive. But their resources are wider, their teaching more comprehensive, and their facilities more far-reaching. They, too, deal with purely academic education as well with vocational training, but they are able to run far more specialised courses in particular trades. They often work in conjunction with the local education authorities or with local industries, and one Formation College is now running special courses for men who propose to start one-man businesses and instructional courses for applicants for the technical branches of the G.P.O.

Such semi-vocational courses are invaluable to men about to be demobilised and who need a quick refresher course to brush up their trade or profession. It was, however, more the academic side to which Mr. Lawson was referring when he spoke of the permanent value of such institutions. If these Colleges are to be incorporated in the educational side of the regular Army, they will do much to dispel the slur of ignorance which is laid, often unjustly, upon the name of the regular soldier. The new Formation Colleges are progressive and efficient in their teaching and are making a most valuable contribution to adult education.

Medical Books Bureau for London

THE Rockefeller Foundation has made over to the Royal Society of Medicine a sum of £61,725 for the purpose of setting up and maintaining for four years a Central Medical Library Bureau. This bureau will have as its first objective the rehabilitation of medical libraries in Europe. Its second and more permanent objective will be to provide a means of rapid interchange of medical knowledge between individuals and institutions.

Correction

WE have received a letter from the L.N.E.R. public relations department pointing out that the diagram labelled Fig. 3 in the article "Railway Tracks: Their Design and Testing" published in the April 1945 issue should have been acknowledged to the L.N.E.R. The letter also states that the first stretch of flat bottom track was laid in an L.N.E.R. main line in July 1939.

The Bookshelf

Colloids—Their Properties and Applications. By A. G. Ward. (London, Blackie, 1945; pp. 133, 28 figures and 5 plates; 5*s*.).

The author presents an up-to-date introductory survey of Colloid Science in 130 pages. Such books perform a definite service to the scientific public: to the student they introduce a subject in the early stages of his career and to the specialist they can afford a bird's eye view of developments off his main beat. Authors who undertake such tasks incur a responsibility to present an accurate and well-balanced view in an interesting way, and Mr. Ward fulfils these obligations: in spite of the small space at his disposal he curbs any inclination to condense his English, and the book remains readable. The diagrams are clear, especially some of the illustrations of molecular structures, but some of the plates are a little less instructive. The indexing is patchy—for instance, under 'flow bi-refringence' might have been noted an important application of its observation discussed on p. 107—and references to the literature might have been a little fuller.

The first half of the book gives a modern and easily understood introduction to the theoretical and practical aspects of Colloid Science in general, though some of the elementary discussion of the structure of matter in the second chapter lies perhaps outside the reasonable scope of this book, and the first chapter might have been covered in three instead of 5½ pages. Towards the middle increasingly more applied problems are discussed, including dusts, smokes, fogs, and the use of foams in fire-fighting, and the reader is led naturally on to the consideration of industrial Colloid Science and the study of living matter, with sections on rubber, cellulose and proteins, clays, varnishes, and detergency. It is perhaps premature to give wide publicity, as though it were an established generalisation, to the view (pp. 104-5) that the molecular weights of the majority of proteins can be expressed as multiples of 17,600 units; there are too many exceptions. To make the book more complete—and more exciting—mention might have been made of genes along with viruses at the end, and this could have led to a better concluding paragraph re-emphasising the importance to every aspect of our life of the study of these aggregates of smaller molecules (chemically or physically held together—the distinction is purely a matter of convention and convenience), and how this study has gone far towards removing the barrier between living and non-living material. The book usefully fills an undoubted gap in the elementary literature.

E. M. Jope

The Religion of Ancient Mexico. By Lewis Spence. (London, Watts, The Thinker's Library, No. 107, 1945; pp. 136, 2*s*. 6*d*.).

Mr. Lewis Spence, who has written extensively on the civilisation of ancient Mexico, here presents in a form adapted to the needs and interests of the general reader a brief account of the highly complex religious system of the Aztec or Nahua as they are more properly called. The Nahua were the dominant people in Mexico when that country was conquered by the Spaniards under Cortez in the early sixteenth century. They had then occupied the country for a short time, after invading it from the north a few centuries previously. They belonged to a lower grade of civilisation than the people they subdued; for they were migratory hunters of the Plains Indian type, while their predecessors in Mexico were heirs of a succession of cultures which had been strongly influenced from the south, probably by the ancient Mayan peoples of Central America, whose monuments and sculpture are the outstanding wonders of American pre-history.

The Nahua adapted the cultural tradition and mode of life of the more advanced people of their conquest who were agricultural. Indeed they appear to have embraced it with enthusiasm; but they brought to it a capacity for organisation which welded the peoples of Mexico into an empire of which the strength and wealth evoked an enthusiastic amazement among the Spaniards, that, nevertheless, did not save it from destruction. The religion of the Nahua is known to us from contemporary accounts, both Spanish and Indian, as well as from the few precious manuscripts in picture writing which have survived. It was in the main an agricultural ritual. That is to say its aim was to ensure the continuance and vigour of the spirit of vegetation on which their food supply and their prosperity depended, as well as to propitiate the personified natural forces—the sun, rain, the winds, and the like—by which the interests of the crops and the people and their rulers might be advanced or harmed. The aims, they believed, were to be attained by periodical sacrifice, and at each seasonal festival they made an appalling offering of men or women, or both, slaughtered on the altar and in numbers occasionally running into thousands. An elaborate use of symbolism and personification combined with the concepts, proper to a hunting people, added by the Nahua to make of Mexican religion and mythology one of the most complex of the systems of religious belief recorded among the less advanced peoples of the world. In this maze the reader will find Mr. Spence a lucid and sure guide.

E. N. Fallaize

British Trees in Winter. By F. K. Makins. (J. M. Dent & Sons, London, 1945; 56 pages, 46 photographs and 40 drawings. 7*s*. 6*d*.)

British Trees in Winter is a rather expensive book which sets out to help non-botanists especially, to recognise our trees in the winter; the aim is praiseworthy. The book is a mixture of the good and the not-so-good. The pictures of trees, taken from photographs lent by the Letchworth (Hertfordshire) Museum are excellent, but their source should have been acknowledged in the body of the book, and not merely on the dust-cover, which most readers will lose. The key for the identification of twigs is clear, and it works. Photographs and key are the good parts of the book. The text, which contains much varied information, would have been improved by careful revision before it was put into print. Revision would have tidied up some loose writing, and would perhaps have suggested to the author that not many of his probable readers were likely to understand the term 'blaze' without explanation. It is unfortunate that the excellent photographs should be accompanied by such rough drawings of the twigs; few of those drawings do justice to their subjects.

B. Barnes

The Biology of Flight. By Frederick L. Fitzpatrick and Karl Stiles. (London, Allen & Unwin; pp. vi + 162; 8*s*. 6*d*.).

This is an entertaining and attractive little book dealing with the biology of all things that fly, not excepting man himself. The first two chapters on the flight of birds, airborne seeds, spores and bacteria, and such creatures as the pterodactyl, flying-fox and flying-fish fall into a class rather separate from the rest of the book, which is straightforward aviation physiology. One is conscious of this division, but it is one which is skated over easily enough: the reader picks up some pleasing facts in the first section.

The first part deals with the aerodynamics and airframe construction of the natural flyers: the later chapters with what happens to a man when he flies through the air in a flying-machine of his own construction. To anyone with a general education in science there is not much new here, but it makes pleasant reading nevertheless, and doubtless this polished simplicity will give the book a great appeal for the reader who has not met the subject before. He, after all, is the person who counts, and although he may not follow, for example, the reasoning of the argument which shows that, even with an oxygen mask, very low air pressures cannot be endured, this is probably the only point in the whole book which will pass him by.

Not least among the pleasing features of the book are the excellent diagrams and photographs, and it is a compliment that the American authors of a book first published in the U.S.A. should have used so many photographs illustrating the work of the R.A.F.

David S. Evans

Social Aspects of Tuberculosis. By S. Roodhouse Gloyne, M.D. (Faber, London; pp. 148; 8*s*. 6*d*.).

It is of vital importance not only to health workers but also to those interested in social problems, that the main facts revealed over the past 100 years regarding the social aspects of tuberculosis, should be

readily available in a short and comprehensive form. It is fair to say that Dr. Gloyne, Pathologist to the London Chest Hospital, has achieved this aim in this interesting book. After discussing the various forms of tubercular disease and surveying the factors which contribute to infection, Dr. Gloyne gives a very full analysis of its incidence according to age and sex in our own community, and traces its steady decline since reasonably accurate figures became available nearly 100 years ago. It is interesting to learn from the tables given that, except for 1929, the decline continued uninterruptedly during the inter-war years, and that the ground lost in the first two years of World War II has since been regained.

The chapters concerning tuberculosis as an industrial hazard and the re-entry of tuberculosis sufferers into employment show the need for very much better provision for rehabilitation and resettlement than we have at the moment, if all the labour and expense of bringing about their cure is not to be lost. Too often a potentially useful citizen becomes a chronic burden, if not a danger, to the community, because of our present inability to provide for his easy adjustment to normal working conditions. Settlements and workshop schemes are not available generally, and it would be interesting to learn how other countries have solved this problem.

One could wish that Dr. Gloyne had devoted even more space to the important contributory factors of nutrition, housing, and unsuitable working conditions with long hours, since it is here that enlightened public opinion may be of the greatest service in the future, especially in reducing the incidence of tuberculosis in young adults. Early diagnosis is invaluable in discovering the infection, but it is even more important to remove the conditions under which it was contracted. Given knowledge and will, and apart from possible social and economic upheavals, the 'Captain of the Men of Death' can be relegated to a very minor role within a lifetime, and well documented and up-to-date books such as Dr. Gloyne's are an invaluable guide to the path which should be followed.

E. S. DUTHIE

Science and Nutrition. By A. L. Bacharach. (Watts, London, 2nd. ed. revised—1945; 142 pp., 5*s*.).

THE first edition of this book was well received and quickly sold out. From its whimsical dedication right up to the concluding words—"For the vast majority of the world's workers what is wanted is not mainly an altered order of courses, or even a better cook and kitchen, but simply more money. With that will inevitably come the purchase of more food by those who need it, and the rest will follow"—so amply proved correct by Britain's wartime experience, it was popular science of the best kind. Written for the interested and educated layman of any class, it served its purpose admirably. Mr. Bacharach appreciates as well as anyone the dangers that may arise from over-simplification and over-writing and he gave little real ground for a scientist to criticise the book on that score. Substantial revision has now been made in the chapters on amino acids, the detection of vitamins and their identification, and the necessity for optimum diets; nearly all the revision owes its origin to the advances made since the first edition. *Science and Nutrition* now costs twice the pre-war price, but is well worth the money.

WM. E. DICK

Elementary Astronomy. By Ernest Agar Beet. (Cambridge University Press, 1945; pp. 110, 8*s*. 6*d*.).

BOOKS on astronomy, some good, some bad, and some indifferent, continue to appear in astonishing numbers. They are designed to meet a variety of needs, and quality is to be assessed by comparison between different attempts to meet the same needs. This little book covers the syllabus in elementary astronomy suggested by the Science Masters' Association and does what it sets out to do remarkably well. The basic stuff is all here—the elementary properties of light; the earth and its rotation and orbital motion; a short description of the constellations; the measurements of time; a little about navigation; the planets; and so on. In fact what Mr. Beet has done is to lay the foundations of astronomy from the very beginning, and when he has finished the job, there they all are—straight and true, easy to see, with no jerry-building. At the end of each chapter there are suggestions for observations of a very elementary kind which the reader can carry out for himself; at the end of the book there are lists of questions and problems, and a bibliography. The line illustrations are good and so are the half-tone plates, including an excellent one of a model of the 200-inch telescope.

DAVID S. EVANS

Night Sky in April

The Moon.—New moon occurs on April 2d 04h 37m U.T. and full moon on April 16d 10h 47m. The following conjunctions take place:

April				
8d 19h	Saturn in conjunction with the moon	Saturn	2°	S.
9d 07h	Mars ,,	Mars	0·2	S.
16d 01h	Jupiter ,,	Jupiter	3	S.
29d 15h	Mercury ,,	Mercury	2	N.

The Planets.—Mercury rises at 5h 13m, 4h 36m, and 4h 11m at the beginning, middle and end of the month respectively, or about half an hour before sunrise, but is too close to the sun for good observations. The planet is stationary on April 11, and attains its greatest western elongation on April 23. Venus can be seen in the western sky for some time after sunset. The planet sets at 19h 45m, 20h 30m, and 21h 19m at the beginning, middle and end of the month respectively. Mars, in the constellation of Gemini in the early part of the month, moves into Cancer before the middle of April. It can be seen throughout most of the night, setting at 3h 16m, 2h 35m, and 1h 51m at the beginning, middle and end of the month respectively. Its distances from the earth vary from 108 to 133 million miles from April 1 to 30. Jupiter is now well placed for observation, rising at 19h 37m, 18h 26m, and 17h 17m at the beginning, middle and end of April respectively. The planet is in opposition to the sun on April 13, that is, the sun, earth and Jupiter are in a line so that there is not a great difference between the time of sunset and the time when Jupiter rises. Jupiter is a little north of α Virginis (Spica) during the month, and the distance of the planet from the earth varies between 416 and 417 million miles from April 1 to 30. The satellite system, or at least the four Galilean satellites, can be seen with binoculars, and the motions of the bodies can be detected in the course of a few hours or less. Saturn is close to δ Geminorum and can be seen throughout a good portion of the night, setting at 2h 44m, 1h 51m, and 0h 56m at the beginning, middle and end of the month respectively. Its distances from the earth vary from 826 to 780 million miles between April 1 and 30. Some readers may wish to search for Uranus and during April it is in the constellation of Taurus close to the fifth magnitude star ι Tauri.

Times of rising and setting of the sun and moon are given below, the latitude of Greenwich being assumed:

April	Sunrise	Sunset
1	5h 37m	18h 32m
15	5h 06m	18h 05m
30	4h 36m	19h 20m

April	Moonrise	Moonset
1	5h 53m	17h 34m
15	17h 51m	5h 16m
22	4h 33m	17h 54m

Amongst the spring constellations Leo is conspicuous and is found by prolonging the line through α and β Ursae Majoris for about 30°. It is easy identifying this constellation from its resemblance to a sickle on one side; on the other side is a group of stars in the form of a triangle. The brightest star in Leo is α Leonis or Regulus, and a small telescope—less than 3-inch aperture—will show a companion at a distance of about 3 minutes of arc from Regulus. Another star γ Leonis, of golden yellow colour, has a greenish-red companion at a distance of less than 4 seconds of arc. As its magnitude is 3·5 it is not a difficult object to see with optical aid.

Those who are interested in meteors may be able to see something of the Lyrids from about April 18-22, which appear to emanate from the constellation of Lyra.

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